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A DISSERTATION

SUBMITTED TO THE FACULTY
OF THE OGDEN GRADUATE SCHOOL OF SCIENCE
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

DEPARTMENT OF PHYSIOLOGY

BY

MARGARETE META HEDWIG KUNDE

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The Journal of Metabolic Research, pp. 399–449
1923

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THE AFTER EFFECTS OF PROLONGED FASTING ON THE BASAL METABOLIC RATE.

By MARGARETE M. KUNDE.*

(From the Hull Physiological Laboratory of the University of Chicago)

The work here reported was undertaken at the direction of Dr. Carlson with the view of securing some measurable and objective data on the after effects of prolonged fasting.

There are a number of well controlled experiments, on man and animals, on the effects of prolonged fasting on metabolism during the fasting period,[1] but no one seems to have investigated the possible after effects of fasting on the basal metabolic rate. We have extensive data on the macro- and microscopic[2] changes induced in the various organs by fasting. We have reports of apparent improvement in mental conditions in man as the result of fasting. The tonus[3] of the stomach increases during fasting. Extensive experiments on some invertebrate groups by Child[4] and his coworkers[5] seem to point to a process of rejuvenescence of tissue by starvation. In diabetes in man it appears that partial starvation, in some cases, increases the capacity of the body to utilize sugar.[6]

Since it is established that the young individual has a higher level of oxidative activity than the adult[7], it would seem to follow that if prolonged fasting actually leads to rejuvenescence or extensive renewal of body cells over that which takes place under ordinary conditions of feeding, such rejuvenescence would be evidenced by an increase in the basal metabolic rate.

It is the purpose of this experiment to determine whether measurable changes occur in the basal metabolic rate as a result of prolonged fasting followed by normal feeding. It seems that this can be done by determining the level of the basal metabolism of the subjects before, during, and after prolonged fasting, keeping the diet, body weight, and mode of living before and after the fast as nearly identical as possible.

Experimental Methods.

The basal metabolism, computed from the oxygen consumption, was used as an index of the oxidative activity of the body

* National Research Council Fellow in Physiology.

when at rest. For this purpose a Benedict portable respiratory apparatus,[8] with suitable modifications adapted to our needs, was used. Two people and three dogs served as subjects.

The pre-fasting period constitutes the control period. During this period, data on the several subjects establishes the average normal levels of the basal metabolic rate, body temperature, pulse rate, respiration rate, and body weight.

There was no attempt made to regulate the quantity or kind of food eaten by the two persons who served as subjects, other than that one of them, M. K., lived in one of the University Residence Halls for women where there is some dietary supervision, so that it is possible for the occupants of this hall to receive wholesome, well-cooked food approximately balanced in the composition of the various foodstuffs, as estimated by the supervising dietitian. This subject was engaged 12-16 hours daily in graduate studies and in teaching. The other person, F. H., was a worker in a small flour mill. The food which he ate was prepared by himself, and since he has a fairly good knowledge of dietetics and nutrition, he was able to make rather accurate estimations of the daily food requirements for a working man in his capacity. In all cases 12 hours elapsed from the time that food was eaten until metabolism tests were made on the two persons in the morning.

The dogs were fed on an accurately weighed maintenance diet. During the control period this consisted of 250 g. of hashed, leaned beef, 100 g. of bread and 250 cc. of whole milk. Cooked bones were fed them from time to time to supply necessary roughage. The dogs were fed once a day, 18 hours before their basal metabolic rates were estimated.

No marked changes occurred in the room temperature in which the tests were made, in spite of the fact that the determinations on M. K. were made daily for a year, and on the other subjects through the changing seasons. The most favorable temperature proved to be between 24.5°-25.5°C. The relatively constant temperature in the metabolism room during the time that tests were made was maintained through several factors. (1) The small room is provided with double doors. (2) It is equipped with an automatic thermostat which guards against over-heating during the winter. (3) The ventilation is such that outdoor air can be admitted equally efficiently through either a small or a large aperture. (4) The metabolism determinations were completed during the summer months by 7 A. M.; during the winter, by 9 A. M. The utilization

of the early morning hours prevented the excessive summer heat from interfering with the experiments. Then, too, the dogs are more easily managed at this time than later in the day, and these regular hours exclude errors due to diurnal variations.[9]

The effect of muscular activity on the metabolism was controlled by having each person relaxed and resting quietly on a couch for at least 30 minutes immediately preceding the test. The dogs were trained to lie quietly on a comfortable pad for at least 45 minutes immediately preceding the determinations and to remain so during the time that they were connected to the respiratory apparatus.

A simple device for connecting the dogs to the Benedict portable respiratory apparatus was perfected. This consists of a rubber dam tightly stretched over one end of a muzzle that serves the same purpose in animal calorimetery that the face mask serves in making determinations of the respiratory exchange of people. The other end of the muzzle is equipped with a metal tube, and a short rubber tubing connects this with the three way valve of the respiratory apparatus. A circumscribed area between the dog's eyes and the corners of the mouth must be cleanly shaven. The dog's nose is gently inserted into the perforation in the rubber dam so that the shaved area makes an air tight approximation with the perforation in the rubber dam. The dogs, when properly trained, offer no resistance to the muzzle. The muzzle is not adjusted until 3 or 4 minutes before the experiment begins. The corner of the mouth must be well inside of the muzzle and all wrinkles carefully smoothed out. The rubber must be pulled far forward under the chin, so that it fits smoothly over the spina mentalis.

Tests for tightness with a dog connected to the Benedict portable respiratory apparatus are made by making a duplicate determination of the oxygen consumed and placing a small weight on top of the spirometer bell during one of the determinations. If the muzzle is not tight the determination made with the weight on the spirometer bell will be much higher. Tests for tightness made in this manner check to within 1 or 2%.

The dogs were not confined to a cage but each lived in a roomy, separate booth with ample space for them to walk about freely. Further precaution to prevent the loss of muscle tonus due to laboratory confinement[10] consisted in vigorously exercising the dogs daily either by taking them out of doors or by allowing them

to play and run about freely two or three hours in a large attic over the laboratory. The dogs had been living in the laboratory from six weeks to four months before experimentation on them began.

The Fasting Period as here used designates the time during which the subjects completely abstained from all foods. They were allowed to drink water *ad libitum.* During the fasting period the two persons continued their daily occupations, as mentioned above. The pulse, temperature and body weight were taken immediately after, and the respiration rate during the determination of the metabolism. Each of the two persons fasted for 15 days. Dog No. 1 fasted for 37 days, dog No. 2, for 40 days, dog No. 3, for 41 days.

The Period After Fasting. The duration of this period varies with the several subjects, but in each case the term is used to indicate the time from the breaking of the fast until the end of the experiment under discussion. For M. K. the length of this period was six months; for F. H. 9½ weeks. For Dog No. 1 this period extended through 9½ months; Dog No. 2 for 4½ months; Dog No. 3 for 3¼ months. The predominant motive during this period was to keep the experimental conditions exactly the same as during the control period. Dogs No. 1 and No. 2 were not fed on the maintenance diet for the first four days of this period because of their inability to retain food. After the first four days each of these dogs received the maintenance diet until the respective body weights of the control period was reached. Then the food was reduced in amount in an attempt to keep the body weight from increasing over that of the control period. The experimental work on Dog No. 3 was interrupted for the first ten days of this period. After that this dog received the maintenance diet until the body weight of the control period was reached.

Methods of Calculation.

All calculations for determining the number of calories of heat produced for 24 hours are based on the amount of oxygen consumed during the experimental period and assuming that the respiratory quotient was .82. Since CO_2 excretions were not estimated it was impossible to determine the actual respiratory quotient for the several subjects. But it has been shown that the respiratory quotient of normal individuals, when in the postab-

sorptive condition, is fairly constant or at most varies only 2 or 3 points from the quotient[11] 0.82, i. e. when the diet is fairly uniform and consists of a mixture of the foodstuffs. It is also known that the caloric value of oxygen varies only 8% from the greatest possible extremes of the respiratory quotient[12] (1.—0.70). If one arbitrarily chooses a respiratory quotient midway between the two extremes, the greatest possible error that could be introduced is about 4%. But since the respiratory quotient normally varies only 2 or 3 points from the quotient 0.82, the error introduced into the calculations by arbitrarily using 0.82 can only be 1 or 2%. This error is far less than would be introduced in attempting to determine the amount of CO_2 excreted during the test with the Benedict portable respiratory apparatus, owing to the great difficulty in accurately weighing the cumbersome soda lime containers and the possibility of excreting more CO_2 than is actually produced in the short period through excessive ventilation of the lungs.

The experimental period for each person was about 10 minutes; for each dog 15 minutes. The graphic method was used to determine the number of cc. of oxygen actually consumed during each period. Care was taken to begin and end the period at the end of a normal respiration. A true base line was traced on the drum by means of a signal magnet during the time that the experiment was in progress. Greater accuracy in measuring the results can be obtained by using this line rather than the edge of the paper. The motor was set in motion 4-5 minutes before the experiment actually began. This assures the complete removal of all of the CO_2 in the circuit and often eliminates wide temperature changes in the spirometer. After the subject is disconnected the motor is allowed to run until the writing point traces a straight line. This point indicates the complete removal of all of the CO_2. The amount of O_2 consumed is indicated, not by the end of the last normal respiration of the subject but at the level where the writing point began to trace a straight line. The paper is removed from the drum and fixed with shellac, laid on a smooth table and the cc. of O_2 consumed measured by means of the spirometer scale according to the scheme which explains Fig. 3.

The distance R B — V B on the measuring scale indicates the actual number of cc. of O_2 consumed by the subject during the period.

The Benedict method, slightly modified and greatly simplified,

was used to convert the cc. of O_2 into calories of heat as follows: If the distance R B — V B equals 2100 cc. of O_2 and the experimental period 10 minutes and 6 seconds; the B. P. 74.1; the temperature of the spirometer at the beginning of the determination 24°.5 C; the temperature at the end of the experiment 25° C; the increase in temperature in the spirometer is .5°C. The average temperature in the spirometer during the experiment is 25°C. Since an increase of temperature of 1° C. equals 1°.8 cc. O_2 per minute (Benedict calibration factor), an increase of .5°C would equal .9 cc. of O_2 per minute. .9 x 10.1 equals 9.9 or 10 cc. of O_2. 2100 cc. of O_2 + 10 cc. equals 2110 cc. of O_2 consumed during the period, corrected for temperature changes in the spirometer. The caloric value of liter of O_2 when the respiratory quotient is .82 equals 4,825.

Log. of 2110	.32428
Log. factor for reducing 25°C and 74.1 mm. B. P. to standard conditions	.95088
Log. of 60 x 24 x 4.825 equals	.84186
	.11702
Subtracting Log. of 10.1	.00432
	.11270
Anti log. of .11270	1296

The total number of calories of heat produced for 24 hours equals 1296.

The average basal metabolism for any subject during a given period is determined by adding together the total numbers of calories of heat produced per 24 hours for the entire period and dividing this number by the number of determinations in the period. The surface area of the dogs was determined by the Meeh's formula.[13] The surface area of the persons was determined by the DuBois and DuBois[14] Ht. Wt. chart. The number of calories produced per kg. of body weight is found by dividing the calories produced per 24 hours by the body weight in kilos. Fractions of calories are not recorded but results are given in the nearest whole numbers. Variations in body weight are recorded in the nearest .1 of a kg. Accuracy beyond this is superficial since log. tables were used in the computations and the retention of urine, or feces, would swing the balance either way to the value of .1 of a kg.

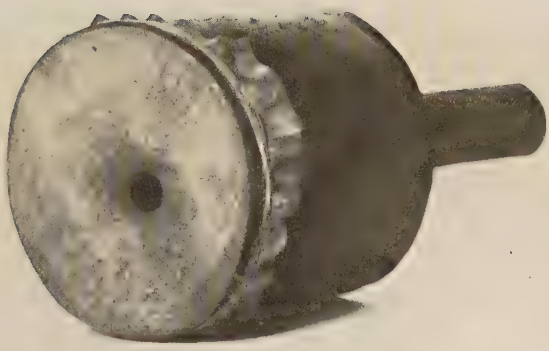

Fig. 1. A simple muzzle for connecting dogs to the Benedict portable respiratory apparatus, or other open or closed respiratory systems.

Fig. 2. Showing dogs under experimentation in the metabolism room. The dog at the left is connected to the Benedict portable respiratory apparatus by means of the muzzle. The dog at the right is resting quietly in preparation for having its basal metabolism determined. The picture was taken at a four minute time exposure, showing the complete quietude of the animals

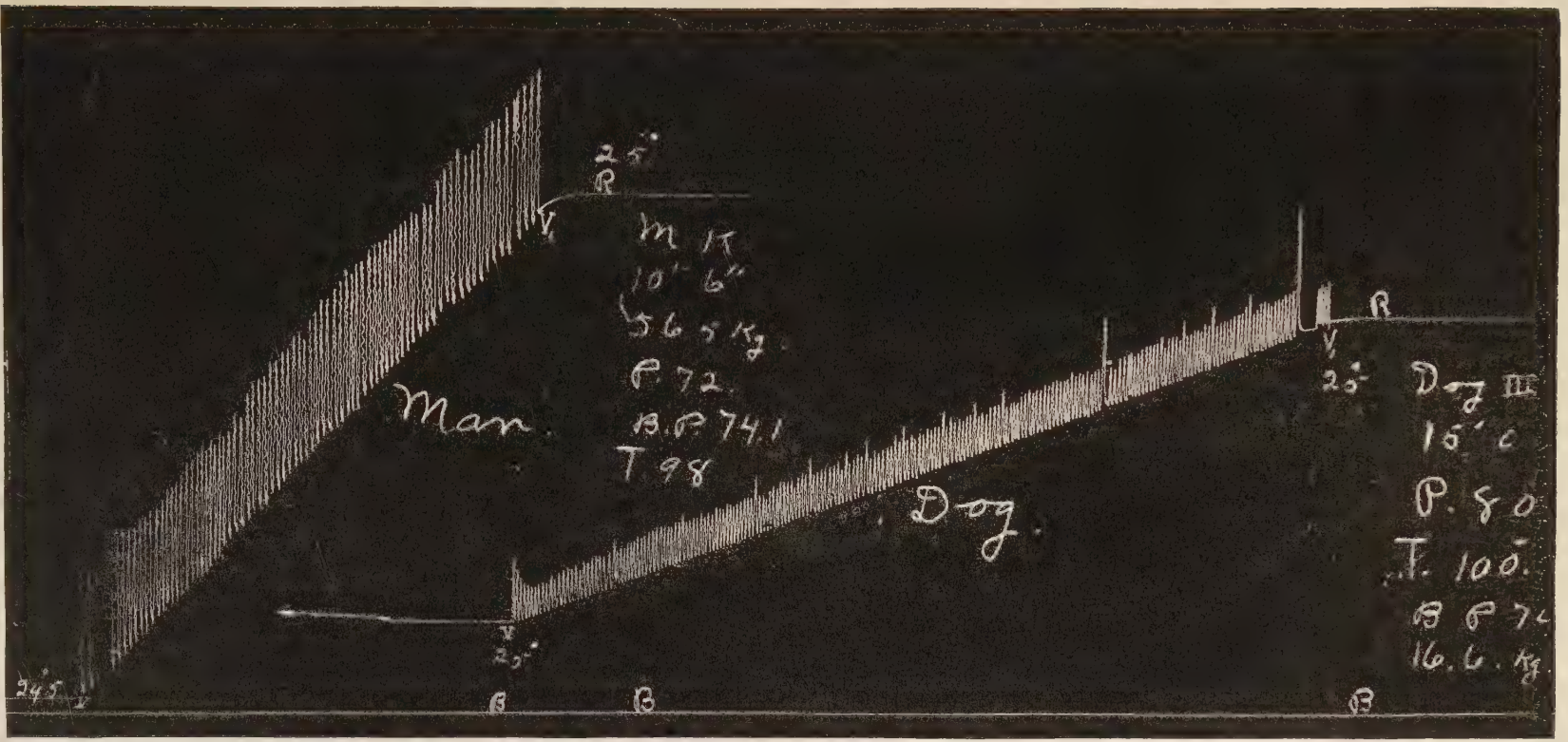

Fig. 3. *B—Base line.*
V—End of the normal respiration which marks the beginning of the period.
V—End of normal respiration where the three way valve was turned to disconnect the subject, and the stop watch stopped.
R—Indicates the level where the writing point attached to the counterpoise of the spirometer began tracing a straight line. This shows that the CO_2 is completely removed from the corcuit.

Results on Man.

Subject M. K. Basal metabolism estimations and other data tabulated were determined daily for the period of one year, excepting for eight days during the holidays, a three-day period when coughing interfered with the technique, and three or four single day periods when the data was rejected due to difficulties with the apparatus.

The Control Period for this subject extended through five months and thirteen days. The body weight during this period varied from 55 to 55.5 kilos. The pulse ranged from 66 to 82 beats per minute. The temperature varied between 97°.06 — 98°.40 F. The surface area, according to DuBois and DuBois Ht. Wt. chart was 1.63 sq. meters. The average basal metabolism for this period was 1375.2 calories per 24 hours. The average number of calories of heat produced per sq. meter of body surface for 24 hours was 843.7. The average body weight was 55.2 kilos. The average number of calories per average kg. of body weight per 24 hours was 24.91. The greatest deviation from the average heat production was 13.6% plus on April 4 and 8.3% minus on September 10. These extremes occur at widely different seasons and this may account for some of the difference as will be discussed later.

Since the pre-fasting period extends through changing seasons and the metabolic rate of this subject was slightly higher in the early spring than in mid-summer, it becomes obvious that a more accurate comparison of the pre- and post-fasting metabolism can be made by using as a control, not the entire six months period, but the ten weeks immediately preceding the fast. This has been done, and gives a slightly different average as can be seen from Table 6.

The Fasting Period. During the 15 days of fasting there was a loss of 7.9 kilos in body weight. This represented 14.3% of the initial body weight. The subject was 17 lbs. underweight at the beginning of the fast; extremely emaciated at the end of the fast. The average body weight during the fasting period was 50.3 kilos. The average basal metabolism during the 15 days of fasting was 1403.2 calories per 24 hours. The highest basal metabolism of this period occurred on the 4th day of the fast. On this day the total heat production per kg. of body weight was 9% higher than the highest metabolism of the control period. The lowest metabolism was reached on the last day of the fast. The total heat

production on this day was 1300 calories. The body weight was 47.6 kilos. The number of calories of heat produced per kg. of body weight was 27.5 calories. This is an increase of 2.6 calories over the average heat production per kg. of body weight during the six months control period. The average heat production for the 15 fasting days per average kg. of body weight was 27.8 calories, an increase of 12.6% above the control metabolism. The pulse rate remained normal; no change occurred in the body temperature during fasting.

The Period After Fasting. In determining the averages for this period the data for the first 5 days was rejected because the body weight was still below normal and the amount of food consumed was considerably below the daily food consumption of the control period.

The Basal Metabolism. The average number of calories of heat produced per 24 hours for the after-fasting period of six months excluding the first 5 days of the period was 1475.7 calories. This is an increase of 100.5 calories per 24 hours over the average of the 5½ months control period. The average body weight was 57.2 kilos. The average number of calories of heat per 24 hours per average kg. of body weight was 25.79, an increase of 3.1% over the 5½ months control period. The average heat production for the first two months of the period was 1465 calories. The average body weight was 56.2. The average number of calories per average kg. of body weight was 26.07, an increase of 6.1% over the basal metabolism of the 10 weeks preceding the fast. The metabolism for the last month (March, 1922) of this period was 1499 calories per 24 hours. The body weight was 57.3 kilos, the average number of calories per average kg. of body weight was 26.16. The average heat production for the first month of the control period (April, 1921) was 1427. The average body weight for that month was 55.2. The average number of calories per kg. of body weight was 25.86. The basal metabolism for Mar. (7th month after the fasting period) was 1.1% higher than for April of the pre-fasting period.

Subject, F. H. — The Control Period for this subject was only 2 weeks in duration. During this time 8 basal metabolism tests were made. The average number of calories of heat produced per 24 hours during this period was 1435.7. The body weight was somewhat variable, ranging from 59.5 to 61.8 kilos. The surface

area at the end of this period was 1.68 sq. metres. The average daily heat production per sq. meter of body surface was 854.1 calories. The temperature varied from 96°.80 to 97°.20. The pulse rate was very constant, varying only between 56 and 60 beats per minute. The average body weight during this period was 61.1 kilos. The average number of calories of heat produced per average kg. of body weight per 24 hours was 23.4 calories. The variations in heat productions were not marked. The greatest increase above the average was 4.8% on November 11 and the greatest decrease was 3.5% below the average on November 1.

The Fasting Period. The loss in body weight during this period was only 6.3 Kilos, or 10.2% of the initial body weight. The basal metabolic rate was higher than normal until the 9th day of the fast. After this it was approximately the same as the normal. The highest metabolism of this period occurred on the 3rd fasting day. At that time it was 10.9% above the average for the control period. The metabolism on the last day of the fasting was 22.6 calories per kg. of body weight. The metabolism on the last day of the control period was 22.8 calories per kg. of body weight. The average daily heat production during the entire fasting period was 1403.9 calories. The average body weight was 58.4 kilos. The average heat production per average kg. of body weight was 24.02 calories, an increase of 2.6% above the average control metabolism.

The body temperature remained normal during the fast. The pulse rate on the last day of the fast was 8 beats less per minute than on the first fasting day.

On November 25th, the 7th day of the fast, the subject began eating non-nutritive cellulose wafers. He continued eating this substance daily until after the metabolism tests were made on December 1. The decrease in the basal metabolism on the day following the ingestion of cellulose was greater than the decrease which had occurred on any previous fasting day. It is interesting to note that the next determination made after the subject had stopped eating cellulose is somewhat higher in spite of the marked lowering in the pulse rate and the loss in body weight. This matter will be taken up in a later report.

The Period After Fasting. The results obtained from this subject are somewhat difficult to present because intermittent fasting days occurring the 5th, 7th and 8th weeks interrupted the con-

TABLE NO. 1

Daily Data for Subject M. K.

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.	Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.
1921	**A. Control Period**				**1921**				
Apr.					May				
1	98	72	55	1416	20	97.8	72	55.5	1440
2	98.1	84	55	1529	21	97.8	74	55.4	1410
3	98	80	55	1470	22	98.1	72	55.2	1363
4	98.1	84	55.1	1563	23	97.8	72	55.2	1390
5	98	72	55.3	1497*	24	97.8	72	55.4	1320
6	98.1	72	55.1	1401	25	97.8	76	55.2	1310
7	98.1	76	55.4	1542	26	98	72	55.5	1396
8	98	68	55.4	1380	27	98.1	76	55.5	1402
9	98.1	70	55.4	1347	28	97.8	74	55.5	1310
10	98.4	74	55.5	1416	29	97.8	76	55.5	1343
11	98.1	70	55.5	1385	30	98	74	55.2	1360
12	98.4	72	55.5	1410	31	98	76	55.4	1390
13	98.4	72	55.3	1448	June				
14	98.3	74	55	1357	1	98.1	78	55.4	1420*
15	98.3	74	55	1332	2	98	76	55.4	1333
16	98.6	76	55	1425	3	98	76	55.4	1353
17	Mechanical Difficulties				4	97.6	76	55.4	1360
18	98.4	72	55	1434	5	97.9	76	55.2	1320
19	98.4	72	55.3	1393	6	98	72	55.4	1360
20	98.4	74	55.5	1453	7	98.1	80	55.2	1420
21	98.1	72	55.5	1363	14	98.1	74	55.2	1340
22	98.4	76	55	1446	15	98.1	74	55.2	1359
23	98.4	76	55	1412	16	98.1	74	55.2	1367
24	98.4	78	55	1438	17	98	76	55.2	1310
25	98.6	80	55	1501	18	98	76	55.4	1361
26	Mechanical Difficulties				19	97.8	72	55.4	1390
27	98.2	72	55.3	1398	20	97.8	74	55.2	1360
28	98.4	76	55.4	1466	21	98	74	55.4	1370
29	98.2	70	55.2	1367	22	97.8	74	55.5	1331
30	98.2	78	55.2	1390	23	97.8	74	55.5	1304
May					24	97.8	74	55.5	1312
1	98	78	55.4	1398	25	98	74	55.5	1461
2	97.6	76	55	1370	26	98	74	55.5	1434
3	97.6	76	55.4	1366	27	97.8	70	55.3	1367
4	97	76	55.2	1380	28	98.2	76	55.4	1491
5	98.1	80	55.4	1467*	29	98	72	55	1348*
6	98.1	76	55.4	1365	30	98	72	55	1330
7	98.2	76	55.2	1356	July				
8	98.4	76	55.2	1375	1	98	74	55	1400
9	98.2	78	55.2	1400	2	97.6	72	55	1371
10	98.5	78	55.5	1410	3	98	72	55	1340
11	98.4	76	55.5	1360	4	98	72	55	1300
12	98.3	76	55.5	1350	5	Mechanical Difficulties			
13	98.4	78	55.5	1420	6	98	68	55	1290
14	98.2	80	55.5	1400	7	98.2	74	55	1450
15	98.4	80	55.5	1420	8	98	72	55	1354
16	97.9	72	55.5	1360	9	98.4	72	55	1310
17	97.6	66	55.2	1380	10	98	74	55	1400
18	98.1	72	55.4	1400	11	98.1	74	55	1388
19	97.6	76	55.5	1465	12	98.1	74	55	1360

TABLE NO. 1—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.	Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.
1921					1921				
July	A. Control Period—Cont.				Sept.				
13	98.1	74	55	1318	1	98	72	55.2	1342
14	98	74	55	1360	2	98	72	55.2	1315
15	98	76	55.1	1390	3	98	72	55.2	1315
16	98	76	55.1	1385	4	98	72	55.2	1327
17	97.8	72	55.2	1374	5	98	72	55.2	1327
18	97.8	74	55.2	1330	6	98.1	66	55.5	1302
19	97.8	78	55	1360	7	97.8	72	55.5	1279
20	98	74	55	1400	8	98.1	74	55.5	1330
21	97.8	74	55	1346	9	98.4	72	55.5	1361
22	98	74	55	1366	10	98.1	70	55.5	1260
23	98	72	55	1374	11	98.1	72	55.5	1270
24	98	72	55	1350	12	98.2	74	55.5	1288
25	98	78	55	1420	13	98.2	74	55.5	1344
26	97.8	72	55	1360					
27	97.8	74	55	1368		B. Fasting Period			
28	97.8	76	55	1348					
29	97.6	76	55	1370	14	98.1	72	55.5	1351
30	98	76	55	1390	15	97.6	72	54.6	1532
31	97.8	76	55	1390	16	98.1	74	53.4	1541
Aug.					17	98.4	80	52	1590
1	97.8	74	55	1342	18	98.2	70	50.8	1500
2	97.8	74	55.1	1346	19	98.4	70	50.7	1525
3	98.2	74	55.2	1325*	20	98.2	75	50.3	1432
4	98	72	55.1	1353	21	98.2	80	49.5	1370
5	98	78	55.5	1345	22	98.4	77	49.2	1348
6	98	76	55.4	1325	23	99	72	49	1305
7	98	74	55.4	1326	24	98.6	74	48.5	1316
8	98	76	55.4	1395	25	98.6	72	48.4	1330
9	98	78	55.4	1410	26	98.4	74	48.1	1300
10	98	78	55.4	1441	27	98.4	74	48	1308
11	98	72	55.4	1392	28	98.2	76	47.6	1300
12	98.1	72	55.2	1410					
13	98	78	55.1	1476		C. Period After Fasting			
14	98	76	55.1	1374	29	98 2	76	48.1	1236
15	98.1	72	55.1	1307	30	98.4	74	50.1	1266
16	98	72	55.1	1330	Oct.				
17	98	78	55	1330	1	98.4	74	51.6	1301
18	98.1	78	55	1400	2	98.4	74	53.2	1310
19	98.1	78	55	1401	3	98.2	76	53.5	1350
20	98	76	55	1330	4	98.3	76	54.7	1317
21	98.4	80	55	1380	5	98.2	75	55.8	1580
22	98	75	55	1340	6	98.4	76	55.5	1430
23	98.4	80	55	1366	7	98.4	74	55.4	1603
24	98.1	76	55	1324	8	98.4	76	55.5	1407
25	98	80	55	1361	9	98.3	76	55.4	1480
26	98.6	82	55	1445	10	98.3	76	55.4	1470
27	98.6	76	55	1360	11	97.8	76	55.5	142_4
28	98.6	76	55	1372	12	98	76	55.6	143_5
29	88.4	74	55	1267	13	97.8	76	55.6	146_0
30	98	70	55.2	1310*	14	97.8	76	55.6	147_0
31	98	74	55	1357	15	97.9	78	55.7	149_7

TABLE NO. 1—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.	Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.
1921	**C. Perio**	**d After**	**Fas**	**ting—**	**Cont'd.**				
Oct.					Dec.				
16	97.9	78	55.7	1490	4	97.4	70	57.2	1428
17	97.9	76	55.8	1521	5	97.4	70	57.2	1404
18	97.9	76	55.8	1508	6	97.4	72	57.2	1438
19	98	78	55.8	1478	7	97.4	72	57.2	1407
20	98.6	78	55.8	1502	8	97.4	74	57.2	1472
21	98.6	78	55.9	1470	9	97.6	74	57.2	1443
22	98.4	74	55.9	1511	10	97.3	74	57	1449
23	98.4	74	55.9	1406	11	97	72	57	1402
24	98.2	78	55.9	1396	12	97.4	78	57	1440
25	Mech	anical	Difficu	lties	13	97.6	78	57	1455
26	98.4	74	55.9	1468	14	98	78	57	1480
27	98.2	74	56	1541	15	97.8	76	57	1493
28	98.2	76	56	1535	16	97.6	74	57	1450
29	98.2	74	56	1483	17	97.4	76	57	1450
30	98.3	74	56	1490	18	97.8	78	57	1501
31	98.2	72	56	1397*	19	97.6	78	57	1530
Nov.					20	97.6	76	57.2	1434
1	98	74	56	1330	21	97.6	74	57.2	1491
2	98.2	70	56	1436	22	97.6	74	57.4	1499
3	98	70	56	1476	23	Mech	anical	Difficu	lties
4	98.1	74	56	1445	24	96.8	66	57.4	1370
5	98	72	56	1427	**1922**				
6	98	72	56	1403	Jan.				
7	98	74	56.2	1471	3	97.9	74	57.4	1420
8	97.6	72	56.3	1387	4	Bad C	old; C	ough I	nter-
9	98	74	56.4	1470		fered			
10	98	80	56.5	1500	5	Cough	Conti	nued	
11	98.1	80	56.5	1472	6	Cough	Conti	nued	
12	97.8	80	56.6	1424	7	97.6	70	57.4	1417
13	98	72	56.6	1520	8	97.8	74	57.4	1439
14	98	71	56.7	1487	9	97.8	74	57.4	1423
15	98	76	56.7	1494	10	97.8	74	57.4	1410
16	98.2	74	56.7	1488	11	97.8	74	57.4	1424
17	98.2	74	56.7	1476	12	97.8	76	57.2	1438
18	98.5	76	56.7	1501	13	97.6	74	57.2	1433
19	98.4	78	56.8	1442	14	97.6	76	57.2	1410
20	98.3	76	56.8	1496	15	97.6	76	57.2	1478
21	98.4	74	56.8	1450	16	Mech	anical	Difficu	lties
22	98.2	74	56.8	1467	17	97.6	80	57.2	1584
23	98.4	76	56.8	1524	18	97.6	74	57.2	1422
24	98.4	84	56.9	1496	19	97.2	76	57.2	1537
25	98.4	84	56.9	1571	20	97.2	72	57.2	1497
26	98.3	72	56.9	1440	21	97.2	72	57.3	1515
27	98.3	72	56.9	1505	22	97.4	70	57.3	1457
28	97.8	74	57	1400*	23	97.6	76	57.3	1471
29	97.4	74	57	1440	24	Mech	anical	Difficu	lties
30	97.6	72	57	1447	25	97.2	76	57.3	1455
Dec.					26	97.2	76	57.5	1380*
1	97.6	74	57	1470	27	97.6	76	57.5	1540
2	97.4	74	57.2	1424	28	97.4	78	57.5	1513
3	97.4	74	57.2	1438	29	97.4	76	57.5	1453

TABLE NO. 1—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.	Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.
1922	**C. Perio**	**d Afte**	**r Fas**	**ting—**	**Cont'd.**				
Jan.					Mar.				
30	97.6	74	57.5	1486	1	97.8	76	57.5	1499
31	97.2	76	57.5	1504	2	98	76	57.5	1490
Feb.					3	97.8	72	57	1491
1	97.4	76	57.5	1480	4	98	74	57.3	1446
2	Mech	anical	Difficu	lties	5	98	74	57.3	1440
3	97.6	80	57.5	1509	6	98	76	57.3	1435
4	97.8	76	57.5	1452	7	98	76	57.3	1532
5	Mech	anical	Difficu	lties	8	98	80	57.3	1560
6	97.8	74	57.2	1444	9	98	80	57.3	1515
7	97.6	76	57.4	1418	10	98.2	80	57.5	1520
8	97.6	76	57.4	1417	11	97.6	82	57.5	1585
9	97.6	76	57.4	1429	12	97.8	76	57.5	1542
10	97.6	80	57.5	1532	13	98	76	57.5	1537
11	97.6	74	57.5	1491	14	98	82	57.5	1505
12	97.6	74	57.5	1460	15	97.8	78	57.5	1493
13	97.8	80	57.5	1557	16	97.6	76	57.5	1467
14	97.2	70	57.5	1400	17	98	82	57.3	1575
15	97.4	76	57.5	1493	18	97.8	76	57.3	1529
16	97.6	80	57.5	1535	19	97.8	76	57.5	1542
17	97.8	76	57.5	1494	20	97.8	76	57.2	1530
18	97.8	76	57.5	1480	21	97.6	82	57.2	1525
19	97.8	84	57.5	1570	22	97.6	82	57.2	1502
20	97.6	86	57.5	1536	23	97.6	80	57.3	1456
21	97.8	80	57.5	1526	24	97.6	76	57.3	1460
22	97.8	82	57.5	1520	25	97.6	76	57.3	1466
23	97.8	86	57.5	1600	26	97.6	76	57.5	1462
24	97.6	80	57	1542*	27	97.6	76	57.5	1438
25	97.8	76	57.5	1544	28	98	78	57.5	1534
26	97.6	80	57.5	1500	29	97.6	76	57.3	1444
27	97.6	76	57.5	1511	30	97.6	76	57.3	1448
28	97.8	76	57.5	1542	31	98	84	57.3	1518

*First Day of Menstruation.

tinuity of this period. The data from January 10th to January 29th was rejected from the calculation of the averages because the conditions, due to these fasts, were not comparable to the conditions of the control period. The conditions were again normal from January 29th to February 15th, when the period ended. The first determination of the basal metabolism of this period was made on the 2nd day after eating. This result is not included in the computation of the average because the body weight had not reached that of the control period. The number of calories of heat produced per 24 hours on the 2nd day after fasting is 46 calories less than on the last day of the fast in spite of the fact

that the body weight had increased 2.5 Kilos. On the 5th day after eating the body weight had returned to normal. At the end of the first week of this period the body had gained 18.2 lbs. The weight on December 11th was 2 kilos more than it was at the end of the control period. The body weight continued to increase throughout this period, at first rapidly, later more gradually. At the end of the period (February 15th) the body weight was 3.2 Kilos. more than it was at the beginning of the fast period. The average body weight for this period was 63.7 Kilos. The food eaten was as near that of the control period as could be estimated without making quantitative determinations.

Basal Metabolism. The average heat production for this period was 1526.3 calories per 24 hours. The average number of calories of heat produced per average kg. of body weight per 24 hours was 23.9. This was an increase of 2.1% above the average heat production per average kg. of body weight during the control period. This period should have been continued for a longer time but the subject refused to eat the amount of food that was consumed during the control period because of the marked tendency to gain in weight.

The body temperature remained the same as during the control period. There was a slight increase in the pulse rate. Bowel movements were more regular than during the control period.

Results on Dogs

Subject, Dog No. 1. Young female. The Control Period. Eight basal metabolism determinations were made on this dog from March 21st to April 9th inclusive. The average heat production for this period was 360.1 calories per 24 hours. The greatest increase above this average was less than 1% (on March 21 and April 5.) The greatest decrease was 1.6% below the normal on April 2nd. The body weight was very constant (10.2 Kilos.), varying only .1 of a kg. during this period. The average number of calories of heat produced per 24 hours per average kg. of body weight was 35.3. The surface area computed by Meeh's formula was .526 sq. meters. The number of calories of heat produced per sq. meter of body surface per 24 hours was 686. The maintenance diet (250 g. meat, 250 cc. milk and 100 g. bread) furnished approximately 861 calories.

The Fasting Period (April 9 to May 15) was 37 days in duration. The total loss of body weight was 4 Kilos. This is 39.3%

TABLE NO. 2
Daily Data for Subject F. H.

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Cal. per 24 Hrs.	Remarks
1921	**A. Control Period**				
Nov.					
3	97.4	56	59.5	1385	Surface Area 1.68 sq. meters.
5	97	56	61	1405	
7	97.2	56	61.7	1436	
9	96.8	58	61	1483	
11	97.4	60	61.4	1490	
13	97	56	61.2	1423	
15	96.8	60	61.2	1452	
17	97.2	60	61.8	1412	10:00 P. M. last meal before fasting period.
	B. Fasting Period				
19	96.4	56	61.2	1523	Second fast day.
21	96.4	54	60.3	1592	Fourth Fast Day.
23	96.2	56	59	1564	Sixth fast day.
25	97	60	58.6	1494	Eighth fast day—Began eating non-nutritive cellulose.
27	96.6	56	57.7	1355	Tenth fast day.
29	96.6	54	57.8	1294	Twelfth fast day.
Dec.					
1	96.4	56	57.1	1212	Fourteenth fast day—Stopped eating cellulose.
3	96.4	48	55.5	1258	Sixteenth fast day.
	C. Period after Fasting				
5	97	62	58	1235	
7	97	64	60.7	1407	
11	96.6	64	63.8	1461	
13	96.8	64	62	1491	
15	96.6	70	63.1	1867	
17	96.8	68	63.1	1465	
19	96.8	70	63.3	1513	
21	97	70	63.7	1551	
24	97	70	63.4	1532	
1922					
Jan.					
3	97	60	64.2	1436	Fasted all day.
5	96.8	58	64	1433	
10	96.4	58	63.5	1491	No food Jan. 7.
14	97.2	62	63.5	1545	No food Jan. 10 and 11.
17	96.8	56	63.8	1334	
21	96.2	58	64	1411	No food Jan. 19.
24	97.4	58	64	1392	No food Jan. 21.
27	96.4	58	63.9	1438	No food Jan. 24.
29	97	62	63.9	1545	Three meals daily.
31	96.8	58	63.9	1520	Three meals daily.
Feb.					
2	96.8	60	64.7	1509	Three meals daily.
4	96.8	66	64.8	1566	Three meals daily.
8	97	62	64.9	1566	Three meals daily.
11	96.8	62	65	1583	Three meals daily.
14	96.2	64	65	1503	Three meals daily.

of the initial weight. The average basal metabolic rate during the fasting period was 305.3 calories per day. The average body weight was 8.04 kilos. The average number of calories of heat per average kg. of body weight was 37.9. The basal metabolism on the last day of the fast was 40.6 calories per kg. of body weight, an increase of 15.01% above the average control metabolism.

The After-Fasting Period (May 16 to March 1).

The Basal Metabolism. Since the after-fasting period of this dog was 9½ months in length and extended through changing seasons and varying physiological conditions, the data becomes much more significant and comprehensive if the period is subdivided into its significant aspects and the averages for these significant subdivisions presented and interpreted in terms of the physiological condition which seems to predominate for the given time. Presentation of the data according to this plan gives us (1) a period of one month when the body is rapidly gaining the weight lost during the starvation. (2) A period of about six weeks during which the body weight was quite constant and approximately the same as during the control period. (3) Various phases of the estrual cycle.

The average daily heat production from May 19th (dog retained food and showed no disturbed symptoms) until June 19th (body weight normal) was 383.4 calories. The average body weight was 9.1 kilos. The average number of calories of heat produced per average kg. of body weight per 24 hours was 42.1, an increase of 19.30% above the control or pre-fasting metabolism. June 19th to August 2nd represents the time when the body weight of the dog was approximately that of the control period. The difference was less than .1 of a kg. at most. The body weight and other conditions are therefore quite comparable to the control period, except that the food had been reduced so that the dog was receiving 132 calories less than the maintenance diet for the control period. The average daily heat production from June 19th to August 2nd was 407.5 calories. The average body weight was 10.2 kilos. The average heat production per average kg. of body weight was 39.9 calories. This is an increase of 13% above the normal control metabolism. The remainder of the period, August 2nd to February 28th inclusive, has been subdivided into several periods in order to determine the effect of the various phases of the estrual cycle on the metabolism.

The Basal Metabolism during the Estrual Cycle. The estrual cycle occurred twice during the after fasting period of this dog. The duration of the first cycle (August 4 to August 26) seemed to be 23 days. The average heat production per 24 hours during this period was 415.4 calories. The body weight was 10.4 kilos. The average heat production per average kg. of body weight was 39.4 calories. The average heat production per 24 hours for the 23 days immediately preceding the rut was 400.1 calories. The average body weight during this time was 10.23 kilos. The average heat production per average kg. of body weight for the 23 days preceding the estrual cycle was 39.2 calories. The basal metabolism during this estrual season in this dog was exactly the same as the metabolism of an equal number of days immediately preceding the rut.

The average number of calories of heat produced per day for the second estrual season (February 14 to February 28) was 482.8. The average body weight was 13.3 kilos. The average heat production per average kg. of body weight was 42.7 calories. The average metabolism for the 15 days immediately preceding this rut season was 499.5 calories per day. The average body weight was 11.2 kilos. The average number of calories of heat produced per average kg. of body weight was 44.5, an increase of 4% above the rut metabolism. The dietary from August 20 to February 28 contained 643 calories. . . .

Dog No. 2, Young Male.

The Control Period (July 29th to September 17th). During this period basal metabolism determinations were made daily with but few interruptions. The average daily heat production was 465.3 calories. The greatest variation from this was an increase of 10% on July 4th and a decrease of 9.8% on September 3rd. The relatively constant body weight for this period was 12.4 kilos. The average number of calories of heat produced per kg. of body weight per 24 hours was 37.54. The surface area was .60 sq. meters. The average number of calories per sq. meter of body surface was 775. The pulse rate varied from 72 to 90. The body temperature from 101°.20—100° F.

The Fasting Period. During this period (40 days) the dog lost 5.2 kilos. of body weight. This was 42% of the control weight. The pulse rate decreased as the fast progressed, reaching the lowest rate of 44 beats per minute on October 19th, the 33rd day

TABLE NO. 3
Daily Data for Subject Dog No. 1

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1921						
Mar.	A.	Control Period				
21	100.8	50	10.3	26	363	100 g. bread, 250 g. meat, 250 c.c. milk
24	101	54	10.2	26	361	Food as above
31	100.8	48	10.2	28	360	Check test 364. " " "
Apr.						
2	101	48	10.3	20	354	" " "
3	101	52	10.3	20	359	" " "
5	100.8	60	10.2	20	363	" " "
6	100.8	58	10.3	22	361	" " "
8						Last feeding at 10:00 A.M.
	B.	Fasting Period				
9	101	54	10.2	26	313	1st Fast Day
10	100.6	56	9.9	32	397	2nd " "
11	100.8	60	9.6	17	335	3rd " "
12	100.8	58	9.5	18	338	Depressed. 4th " "
13	100.8	65	9.4	16	347	Depressed. 5th " "
14	100.9	70	9.2	17	366	6th " "
15	101.1	60	9.2	16	363	7th " "
16	101.2	66	9	16	347	Check test 347. 8th " "
17	101.8	72	9	17	371	9th " "
18	101.4	66	8.8	15	301	10th " "
19	100.8	53	8.7	14	286	11th " "
20	100.8	53	8.6	14	315	12th " "
21	100.6	50	8.5	15	299	Check test 302. 13th " "
22	100.6	51	8.4	14	296	14th " "
23	100.6	54	8.3	20	324	15th " "
24	100.7	52	8.2	13	343	16th " "
25	100.6	50	8.2	13	307	17th " "
26	100.6	58	8.1	14	286	18th " "
27	100.1	50	8.1	12	272	19th " "
28	100.9	50	8.1	14	272	20th " "
29	100.8	45	8	12	279	Enema given. 21st " "
30	100.8	45	7.8	15	280	22nd " "
May						
1	101.6	54	7.7	13	284	23rd " "
2	101.6	51	7.6	11	272	24th " "
3	101.6	45	7.6	14	277	25th " "
4	101.6	53	7.4	13	282	26th " "
5	101.2	54	7.4	12	261	27th " "
6	101	43	7.3	12	282	28th " "
7	102.5	114	7.2	26	332	Depressed; vomited. 29th " "
8	102	110	7.1	13	347	Enema given. 30th " "
9	101.3	66	7	12	295	31st " "
10	100.8	90	6.9	11	278	32nd " "
11	101	102	6.8	11	282	33rd " "
12	101.2	86	6.7	11	270	34th " "
13						Mechanical Difficulties.
14	101		6.5	12	264	36th " "
15	101		6.4	12	271	Moribund. 37th " "
16	100.2	66	6.4	10	260	Fed 50 c.c. milk; vomited.
	C.	Period after Fasting				
17	101.6	64	6.3	17	321	Vomited after each feeding.

TABLE NO. 3—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
May						
18	101	62	6.2	12	300	Began to retain food; 100 g. bread, 250 g. meat, 250 c.c. milk
19	101.4	66	6.3	16	311	Vomiting ceased. Food as above
20	101.4	68	7	16	391	" " "
21	101.2	60	7.4	26	345	Dog apparently in good condition. " " "
22	101.2	66	7.7	22	354	" " "
23	101.4	62	8	25	360	" " "
24	101.4	62	8.1	25	379	" " "
25	101.4	66	8.3	23	355	" " "
26	100.8	70	8.6	18	357	Check test 360. " " "
27	101	68	8.7	25	397	" " "
28	100.9	68	8.8	23	376	" " "
29						Mechanical Difficulties.
30	101	70	8.9	25	387	" " "
31	100.8	68	9	25	368	" " "
June						
1	100.4	70	9.1	18	381	" " "
2	100	66	9.2	18	387	" " "
3	100.4	68	9.3	17	389	" " "
4	101	69	9.4	18	366	" " "
5	101	68	9.5	17	414	" " "
6	101	68	9.3	18	414	" " "
7	101	70	9.2	18	375	Vomited " " "
8	101.4	70	9.2	16	393	" " "
9	101.4	62	9.3	30	393	" " "
10	101.6	58	9.5	20	331	" " "
11	101.2	60	9.6	30	381	" " "
12	101.2	58	9.6	30	400	Check test 402. " " "
13	101	66	9.7	15	365	" " "
14	101.2	64	9.8	34	416	" " "
15	101.2	66	9.9	34	399	Check test 400. " " "
16	100.6	66	10	36	408	Did not eat all food.
17	100.6	62	10	34	395	" " "
18	100.6	62	10.2	40	423	Did not eat all food.
19	100.6	64	10.3	40	412	Body weight back to normal. " " "
20	101.6	66	10.2	34	423	" " "
21	100.8	76	10.3	40	412	Did not eat all food.
22	100.8	70	10.2	24	455	Depressed. " " "
23	101.1	60	10.2	35	424	" " "
24	101.1	64	10.3	24	412	Did not eat all food.
25	101.2	68	10.2	35	413	250 g. meat, 75 g. bread, 250 c.c. milk
26	100.6	66	10.2	28	415	Food as above
27	100.9	66	10.2	29	395	" " "
28	100.8	68	10.2	22	425	" " "
29	100.6	68	10.2	30	448	" " "
30	101	68	10.2	16	445	" " "
July						
1	101	68	10.2	24	445	" " "
2						Mechanical Difficulties.
3	101	64	10.2	22	418	" " "

TABLE NO. 3—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
July						
4	101	68	10.2	30	433	Food as above
5	100.6	72	10.2	22	415	" " "
6	100.6	72	10.2	26	411	" " "
7	101	64	10.3	26	371	" " "
8	101	72	10.2	28	354	" " "
9	101.3	72	10.2	31	401	" " "
10	101	64	10.2	24	402	Check test 406. " " "
11	101	66	10.2	16	411	" " "
12	101	68	10.2	22	413	" " "
13	101.6	66	10.2	30	415	" " "
14	100.8	66	10.2	15	401	" " "
15	100.4	68	10.2	15	371	" " "
16	100.4	66	10.2	16	354	" " "
17	100.5	63	10.2	18	354	" " "
18	100.4	62	10.2	14	371	" " "
19	100.8	66	10.2	21	411	" " "
20	100.6	66	10.3	16	410	" " "
21	100.8	68	10.2	16	415	" " "
22	100.6	68	10.3	16	400	" " "
23	100.8	62	10.2	18	395	" " "
24	100.8	66	10.2	18	412	200 g. meat, 75 g. bread, 250 c.c. milk
25	101	66	10.3	18	385	Food as above
26	100.6	70	10.2	20	411	" " "
27	100.6	70	10.3	20	411	" " "
28	100.8	58	10.2	40	397	" " "
29	100.9	68	10.3	40	408	" " "
30	101.2	67	10.2	21	423	" " "
31	100.6	68	10.3	18	415	" " "
Aug.						" " "
1	100.4	66	10.3	18	402	" " "
2	100.6	66	10.4	18	410	" " "
3	100.6	66	10.3	18	420	" " "
4	101	72	10.4	20	435	Rut appeared. " " "
5	101	72	10.4	28	425	" " "
6	100.4	74	10.4	17	412	" " "
7	100.4	66	10.4	16	412	" " "
8	100.4	64	10.3	17	415	" " "
9	100.2	66	10.3	16	400	" " "
10	100.6	66	10.3	16	380	" " "
11	100.4	66	10.3	16	412	" " "
12	100.6	68	10.4	16	427	" " "
13	100.4	74	10.4	18	392	" " "
14	100.4	66	10.4	24	404	" " "
15	100.6	68	10.4	16	382	Very drowsy. " " "
16	100.6	68	10.4	15	400	" " "
17	101	61	10.4	16	415	" " "
18	101	66	10.4	20	438	" " "
19	100.2	70	10.4	20	431	" " "
20	100.2	66	10.4	30	450	200 g. meat, 50 g. bread, 250 c.c. milk
21	101	66	10.4	16	413	" " "
22	100.8	68	10.4	16	423	" " "
23	100.4	70	10.4	16	421	" " "

TABLE NO. 3—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
Aug.						
24	100	66	10.3	16	420	Food as above
25	100.8	66	10.4	20	423	" " "
26	100.8	62	10.4	20	432	Rut ceased. " " "
27	100.8	64	10.4	20	389	" " "
28	100.8	64	10.5	20	342	" " "
29	101.2	56	10.4	20	252	" " "
30	100.1	54	10.4	20	340	" " "
31	100.6	50	10.4	23	340	" " "
Sept.						
1	101	57	10.4	14	356	" " "
2	101.2	66	10.4	24	370	" " "
3	101.6	70	10.4	24	438	" " "
4	101.4	64	10.4	24	435	" " "
5	101.1	62	10.5	20	435	Slight amount of shivering. " " "
6	101.2	70	10.5	22	443	" " "
7	100.6	68	10.4	16	417	" " "
8	100.8	59	10.4	16	355	" " "
9	100.1	60	10.4	16	337	" " "
10	101	80	10.5	14	403	" " "
11	100.8	66	10.5	14	368	" " "
12	100.9	64	10.4	16	377	" " "
13	100.9	60	10.5	16	376	Slight amount of shivering. " " "
14	100.7	70	10.5	16	359	" " "
15	100	66	10.5	16	365	" " "
16	100	60	10.5	15	369	Check test 369. " " "
17	100.1	64	10.4	15	394	" " "
18	100	60	10.4	15	381	" " "
19	100.1	66	10.4	16	364	" " "
20	100	60	10.4	16	418	" " "
21	100.1	62	10.3	16	342	" " "
22	100.1	68	10.3	16	350	" " "
23	100	66	10.4	16	369	" " "
24	100	66	10.4	16	371	" " "
25	100.1	66	10.4	16	370	" " "
26	100.2	66	10.4	16	360	" " "
27	100	68	10.4	15	373	" " "
28	100.1	66	10.4	16	370	" " "
29	100.5	66	10.4	16	372	" " "
30	100	64	10.4	16	376	" " "
Oct.						
1	100.2	64	10.4	16	373	" " "
2	100.2	62	10.4	16	371	" " "
3	100.1	64	10.4	15	373	" " "
4	100	64	10.4	16	375	" " "
5	100.2	70	10.4	16	405	Slight amount of shivering. " " "
6	100	64	10.4	16	360	" " "
7	100	66	10.4	16	360	" " "
8	100.2	70	10.5	16	390	" " "

TABLE NO. 3—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
Oct.						
9	100.1	70	10.5	16	372	Food as above
10						Mechanical difficulties.
11	100.1	66	10.5	16	379	" " "
12	100.2	72	10.5	16	376	" " "
13	100	72	10.5	16	413	" " "
14	100	76	10.5	18	400	" " "
15	100	80	10.5	18	422	" " "
16	100	80	10.6	20	422	" " "
17	100	84	10.6	16	386	" " "
18	100.2	80	10.6	15	382	" " "
19	100	74	10.6	18	370	" " "
20	100.4	78	10.6	16	395	" " "
21	101	78	10.6	16	415	" " "
22	100.5	66	10.6	16	398	" " "
23	101.1	62	10.6	16	372	" " "
24	100	58	10.7	18	369	" " "
25						Mechanical difficulties.
26	100	64	10.7	20	370	" " "
27	100.6	72	10.8	16	399	Check text 399.
28	100.2	78	10.8	16	401	" " "
29	100.2	78	10.8	16	400	" " "
30	100.2	78	10.9	16	386	" " "
31	100	74	10.9	18	399	" " "
Nov.						
1	101	82	10.9	20	416	" " "
2	100.8	84	10.9	20	429	" " "
3	100.8	68	10.9	16	393	" " "
4	100.6	54	10.9	16	393	" " "
5	101	54	10.9	16	393	" " "
6						No determination.
7	100.8	62	10.9	16	400	" " "
8	100.1	62	10.8	18	406	" " "
9	100.1	54	10.8	16	406	" " "
10	100.1	68	10.7	16	444	" " "
11	101	60	10.7	16	440	" " "
12	100.8	60	10.7	16	415	" " "
13	100.1	66	10.7	16	406	" " "
14	101	66	10.7	16	448	Diarrhoea
15	101	68	10.7	18	459	" " "
16	101	56	10.6	18	432	" " "
17	100.5	55	10.7	18	450	" " "
18	100	64	10.7	20	469	Check test 471.
19	100.8	68	10.7	16	476	" " "
20	100.8	66	10.8	29	423	" " "
21	100.1	54	10.8	16	431	" " "
22	100.2	68	10.8	16	488	" " "
23	101	58	10.7	20	487	" " "
24	101	60	10.8	18	473	" " "
25	101	80	10.8	18	435	" " "
26	101	80	10.8	16	400	" " "
27	101	76	10.8	16	435	" " "
28	101	62	10.8	16	485	" " "

TABLE NO. 3—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
Nov.						Food as above
29	100.8	64	10.8	16	440	" " "
30	100.8	52	10.8	16	491	" " "
Dec.						
1	101	53	10.8	20	463	Check test 468. " " "
2	100.8	66	10.9	12	450	" " "
3	100.1	64	10.8	12	444	" " "
4	101	60	10.8	16	521	Check test 521. " " "
5	101	60	10.8	12	512	" " "
6	101	60	10.8	12	500	" " "
7	101	66	10.8	16	521	" " "
8	101.5	54	10.9	18	515	" " "
9	101.5	60	11	16	511	" " "
10	101	60	10.9	16	501	" " "
11	101	66	10.9	20	477	" " "
12	101	66	10.8	16	474	" " "
13	101	66	10.9	16	500	" " "
14	100.8	66	10.9	16	477	" " "
15	100.1	72	10.9	18	540	" " "
16	100.1	72	10.9	16	546	" " "
17	101	74	10.8	16	528	" " "
18	101	60	10.8	16	490	" " "
19	101	75	10.8	16	521	" " "
20	101	72	10.8	18	486	" " "
21	101	72	10.8	18	492	" " "
22	101	74	10.8	16	478	" " "
23	101	66	10.9	16	482	" " "
1922						
Jan.						
3	101	54	10.6	16	455	" " "
4	101	62	10.6	18	460	
5	101	68	10.7	16	401	" " "
6	101	70	10.7	16	484	" " "
7	101	68	10.7	16	454	" " "
8	101	68	10.7	16	403	" " "
9	100.8	68	10.8	18	431	" " "
10	101	80	10.8	20	482	" " "
11	101	85	10.8	16	496	" " "
12	101	62	10.8	16	426	" " "
13	100.8	66	10.8	12	485	" " "
14	101	64	10.8	16	443	" " "
15	101	72	10.8	18		B. M. R. rejected. " " "
16	101	68	10.8	16		" " " " " "
17	101	68	10.9	16	487	" " "
18	101	58	10.9	16	475	" " "
19	100.8	62	10.9	16	478	Check test 478. " " "
20	100.8	54	11	16	454	Check test 457. " " "
21	100.5	54	11	16	457	" " "
22	100.8	60	11	18	392	" " "
23	100.8	68	11	18	482	" " "
24	100.8	68	11	18	482	" " "
25	100.8	64	11	16	437	" " "
26	100.8	62	11.1	18	428	" " "

TABLE NO. 3—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
Jan.						
27	100	60	11.1	18	454	Food as above
28	100	72	11.1	18	480	" " "
29	100.4	60	11.2	20	482	" " "
30	100.6	66	11.2	16	445	" " "
31	100	60	11.2	16	514	Check test 445. " " "
Feb.						
1	100	72	11.3	16	479	" " "
2	100	60	11.2	16	497	Check test 498. " " "
3	100.2	64	11.3	16	525	" " "
4	100.2	64	11.2	16	485	" " "
5						Basal metabolism deter- " " "
6	99.9	58	11.2	14	524	mination discarded. " " "
7	99.8	64	11.3	16	500	" " "
8	100	60	11.3	16	507	Check test 523. " " "
9	100	52	11.3	16	539	" " "
10						Mechanical difficulties.
11	100	58	11.3	18	487	" " "
12	101.2	68	11.3	16	517	" " "
13	100.8	76	11.3	14	512	" " "
14	100	70	11.3	16	439	Rut began. " " "
15	100.2	72	11.3	16	530	Check test 513. " " "
16	00.2	78	11.3	16	451	" " "
17	100.2	64	11.3	18	453	Check test 458. " " "
18	100	58	11.3	18	479	" " "
19	101	72	11.3	18	496	" " "
20	100.4	72	11.2	16	437	Check test 434. " " "
21	100.4	68	11.3	18	448	" " "
22	100	62	11.3	18	448	Check test 450. " " "
23	100.2	64	11.3	18	517	Check test 523. " " "
24	100.4	68	11.3	16	498	Check test 501. " " "
25	106.6	60	11.3	18	524	" " "
26	100.6	68	11.3	18	501	Check test 505. " " "
27	100.2	64	11.3	18	528	" " "
28	100.1	64	11.3	18	493	" " "

of the fast. Following this there was a slight increase. There was no change in the body temperature during the fasting.

The basal metabolism slightly increased during the 2nd and 3rd day of the fast, reaching 7% above the average normal control metabolism on the 3rd day. After this there was decrease in the number of calories as the body weight diminished, but even during the lowest level of the fasting (40th day) the number of calories of heat produced per kg. of body weight was higher than the level of the lowest control metabolism. The average number of calories of heat produced per day during this period was 391.8. The average body weight was 9.78 kilos. The aver-

age heat production per kg. of body weight per 24 hours was 40.0 calories.

Period after Fasting. The dog suffered severe gastric and other disturbances during the first three days of this period; therefore the data for these days was rejected in the determination of averages. After the 4th day the dog was fed on the maintenance diet of the control period until its body weight had returned to normal.

The Basal Metabolism. The average heat production from the time that food was retained (November 1) until the original body weight had been reached (January 4) was 483.7 calories per 24 hours. The average body weight was 10.7 kilos. The average heat production per kg. of body weight per 24 hours was 45.2, an increase of 20.4% over the control average. The average heat production from the time that the normal body weight had been regained until experimentation on the dog ceased (April 6) was 515.6 calories. The average body weight during this time was 12.9 kilos, an increase of .5 kg. above the normal. The average number of calories of heat produced per average kg. of body weight per 24 hours was 39.98, an increase of 6.5% above the control period, 5½ months after the fast had ceased.

Dog No. 3, Old Female (Multipara).

The Control Period (October 17 to December 23). During this period 24 daily metabolism tests were made. The average daily heat production for this period was 515.5 calories. The greatest deviation from the average metabolism was an increase of 5.3% on October 27th and a decrease of 8.4% on October 30th. The body weight varied from 11.8 to 12.2 kilos. The average body weight was 12 kilos. The average heat production per average kg. of body weight per 24 hours was 42.9 calories. The temperature varied from 100°F. to 101°F. Pulse ranged from 60 to 74. This dog was fatter than either of the others and apparently much older. The surface area was .587 sq. meters. The average heat production per sq. meter of body surface was 941 calories per 24 hours.

The Fasting Period. The loss in body weight was 4.5 kilos., 45% of its original weight. The average body weight during this period was 8.73 kilos. The average heat production per 24 hours was 379.4 calories. The average heat production per kg. of body weight was 43.45, 1.2% higher than the average for the control

TABLE NO. 4
Daily Data for Subject Dog No. II

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1921	A.	Control Period				
July						
29	101.2	88	12.4	28	504	250 g. meat, 100 g. bread, 250 c.c. milk
30	101.	90	12.4	28	508	Slight movement. Food as above
31	101.	88	12.3	15	495	Check test 499. " " "
Aug.						
1	101.	76	12.4	25	485	" " "
2	101.	76	12.4	24	435	" " "
3						Data rejected. Restless.
4	101.4	76	12.5	25	515	Check test 510. " " "
5	101.	76	12.4	23	495	" " "
6	100.6	76	12.4	23	440	" " "
11	101.2	72	12.5	26	476	Check test 476. " " "
12	101.2	84	12.4	35	491	" " "
13	101.	78	12.3	20	473	" " "
14	101.	72	12.3	20	444	" " "
15	100.6	72	12.3	26	481	Check test 484. " " "
16	100.6	76	12.4	24	450	" " "
20	101.1	80	12.4	24	462	" " "
21	101.1	80	12.3	26	493	" " "
22	100.	90	12.4	18	473	" " "
23	101.	80	12.4	26	450	" " "
24	101.	80	12.3	14	476	" " "
25	101.	76	12.4	18	470	" " "
26	101.	80	12.4	20	491	" " "
27	101.2	68	12.4	28	482	" " "
28	101.2	70	12.5	55	486	Rapid resp. due to humidity
29	101.	80	12.4	20	486	Food as above
30	101.	70	12.3	20	490	" " "
31	101.1	70	12.4	58	452	" " "
Sept.						
1	100.8	68	12.4	42	434	" " "
2	100.8	64	12.4	16	424	Check test 429. " " "
3	100.8	64	12.4	16	420	" " "
4	101.	70	12.3	18	437	" " "
5	100.9	72	12.3	24	440	" " "
6	101.	74	12.4	22	463	" " "
7	100.9	76	12.4	20	470	" " "
8	101.	72	12.3	16	435	" " "
9	101.	60	12.3	16	417	" " "
10	100.8	80	12.4	15	420	" " "
11	101.2	78	12.4	14	464	" " "
12	100.	80	12.3	14	423	" " "
13	100.	80	12.4	15	486	" " "
14	100.6	70	12.4	16	489	" " "
15	101.	74	12.4	16	465	" " "
16	100.3	72	12.4	15	454	Last feeding before fast at 10:00 A.M.
	B.	Fasting Period				
17	100.4	80	12.4	15	444	1st Fast Day
18	100.4	67	11.9	14	470	2nd " "
19	100.4	70	11.9	14	499	3rd " "
20	100.6	70	11.7	16	459	Check test 456. 4th " "

TABLE NO. 4—(*Continued*)

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks		
1921								
Sept.							Fast	Day
21	100.2	60	11.7	10	439		5th	" "
22	100.2	60	11.4	12	454		6th	" "
23	100.3	68	11.2	12	459		7th	" "
24	100.2	60	11.1	10	461		8th	" "
25	100.2	55	10.9	10	400		9th	" "
26	100.4	60	10.8	8	429		10th	" "
27	100.4	60	10.6	10	440		11th	" "
28	100.2	58	10.6	10	410		12th	" "
29	100.2	58	10.3	8	409		13th	" "
30	100.4	60	10.1	8	457		14th	" "
Oct.								
1	100.2	60	10.2	8	411		15th	" "
2	100.4	58	10.3	10	391		16th	" "
3	100.4	60	10.2	8	429		17th	" "
4	100.2	55	10.1	10	490		18th	" "
5	100.2	55	10.	10	588	Slight Amount of Shivering.	19th	" "
6	100.4	66	9.9	8	508		20th	" "
7	100.2	58	9.8	8	376		21st	" "
8	100.2	58	9.6	8	362		22nd	" "
9	100.	56	9.4	8	347		23rd	" "
10	100.2	56	9.4	8	335	Very alert and playful.	24th	" "
11	100.4	48	9.3	8	317		25th	" "
12	100.3	52	9.2	7	346		26th	" "
13	100.8	52	9.	8	355		27th	" "
14	100.4	52	8.9	7	320		28th	" "
15	100.4	47	8.9	8	352	Check test 358.	29th	" "
16	100.2	47	8.8	8	340		30th	" "
17	100.4	50	8.7	8	345		31st	" "
18	100.2	48	8.6	7	319		32nd	" "
19	100.2	44	8.5	7	325		33rd	" "
20	100.4	54	8.4	8	324		34th	" "
21	101.	51	8.2	8	314		35th	" "
22	101.	51	8.2	7	308	Check test 309.	36th	" "
23	101.	54	7.8	8	326		37th	" "
24	101.5	50	7.9	8	327		38th	" "
25						Mechanical difficulties.	39th	" "
26	101.	57	7.8	7	305		40th	" "
27	101.	55	7.7	7	283	Fed 20 g. meat immediately after taking determination. Vomited.	41st	" "
	C.	Perio	d Afte	r Fast	ing			
28	101.	78	7.5	15	326	Vomited, convulsions. Fed 40 c.c. milk.		
29	103.	88	7.3	13	411	Fed 50 c. c. milk, 25 g. bread.		
30	103.	90	7.2	12	425	50 c.c. milk; convulsions, vomiting ceased.		
31						Violent convulsions, which ceased after 3:00 P.M.		
Nov.								
1	102.	84	7.2	11	442	250 g. meat, 100 g. bread, 250 c.c. milk		
2	102	66	7.7	12	349	Food as above		

TABLE NO. 4—(*Continued*)

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1921						
Nov.						
3	101	60	7.7	18	327	
4	101	60	7.8	16	347	Food as above
5	101	62	8.1	16	388	" " "
6	100.8	62	8.2	12	393	" " "
7	100.8	64	8.4	12	395	" " "
8	100	70	8.7	14	492	" " "
9	101	68	8.9	12	471	" " "
10	101.2	76	9	14	494	" " "
11	101	80	9.2	14	520	" " "
12	102	80	9.3	16	579	Check test 583. " " "
13	101	66	9.8	16	434	Very drowsy. " " "
14	101.2	78	10	16	499	" " "
15	101	74	10.1	16	485	" " "
16	101.2	64	10.1	16	504	" " "
17	101	62	10.2	16	469	" " "
18	101	60	10.4	16	457	" " "
19	101	66	10.4	16	507	" " "
20	101	62	10.5	14	427	" " "
21	100.5	62	10.6	16	448	" " "
22	101	70	10.9	16	527	" " "
23	101	80	11	18	630	" " "
24	101	76	11.1	20	535	" " "
25	101	76	11.2	16	490	" " "
26	101	80	11.2	16	524	" " "
27	100	76	11.3	18	499	" " "
28	101	60	11.3	20	477	" " "
29	101	64	11.4	12	459	" " "
30	101	68	11.4	14	500	" " "
Dec.						
1	101	66	11.4	14	463	" " "
2	102	70	11.6	14	546	" " "
3	102	80	11.6	16	560	" " "
4	100.5	74	11.6	18	497	" " "
5	101	72	11.8	18	473	" " "
6	101	64	11.8	14	503	" " "
7	100.5	66	11.8	16	501	" " "
8	100	68	11.8	16	500	Check test 505. " " "
9	100	62	11.9	16	491	" " "
10	101.2	72	12	16	500	" " "
11	101	62	12.1	14	491	Very drowsy. " " "
12	101	64	12.1	14	497	" " "
13	100.2	70	12.2	16	494	" " "
14	100.2	70	12.2	18	493	" " "
15	101.5	72	12.2	14	522	" " "
16	101	60	12.2	14	502	" " "
17	101	65	12.2	14	499	" " "
18	100	62	12.2	16	490	" " "
19	100	62	12.3	14	498	" " "
20	100	66	12.2	16	528	" " "
21	100	68	12.2	16	516	" " "
22	100.4	62	12.2	16	500	" " "
23	100.4	68	12.2	16	510	" " "

TABLE NO. 4—(*Continued*)

Date 1992	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
Jan.						
3	100.4	61	12.4	14	480	Body weight back to normal.
4	100.5	68	12.4	16	485	Food as above
5	100	70	12.5	20	500	" " "
6	101	68	12.5	14	508	" " "
7	100	60	12.5	16	445	" " "
8	100.5	66	12.5	20	446	" " "
9	100	64	12.5	14	456	" " "
10	100	64	12.6	16	437	" " "
11	101	80	12.8	20	508	" " "
12	101	70	12.8	16	499	200 g. meat, 100 g. bread, 250 c.c. milk
13	101	64	12.8	16	454	Food as above
14	101	72	12.8	16	576	" " "
15	100.8	64	12.8	18	481	" " "
16	101	64	12.8	16	498	" " "
18	101	72	12.8	14	504	" " "
19	100.8	64	12.8	16	504	" " "
20	100.8	70	12.8	18	510	" " "
21	100.1	72	12.8	14	565	" " "
22	100.8	76	12.7	16	418	" " "
23	100.1	72	12.6	16	477	" " "
24	101	60	12.7	16	460	Check test 460.
25	100	60	12.7	14	424	" " "
26	100	66	12.7	18	466	" " "
27	100	60	12.7	18	464	" " "
28	100	58	12.7	16	462	" " "
29	100.4	52	12.6	18	501	" " "
30	101	68	12.7	18	555	" " "
31	101	70	12.7	16	603	Check test 611.
Feb.						
1	100.5	56	12.7	20	491	" " "
2	101	56	12.6	20	485	Check test 497.
3	100	58	12.7	16	468	" " "
4	100	64	12.6	18	510	" " "
6	100	64	12.7	14	524	" " "
9	100	50	12.8	16	580	" " "
10	101	64	12.8	16	514	Check test 530. 200 g. meat, 50g. bread, 250 c.c. milk.
11	101.5	68	12.7	14	583	Food as above
12	100.2	74	13.8	14	545	Check test 543.
13	101	74	12.8	18	524	Check test 519.
14	101	72	12.7	16	563	" " "
15	101	72	12.7	16	610	" " "
16	101.1	76	12.7	18	540	" " "
17	101.2	76	12.7	20	546	" " "
18	100.8	76	12.7	20	538	" " "
19	100.8	78	12.7	22	606	" " "
20	100.8	78	12.7	16	627	" " "
21						Mechanical difficulties.
22	100.2	72	12.7	22	529	" " "
23	100.2	74	12.8	14	620	" " "
24	100.2	68	12.7	14	544	Check test 531.
25	100.2	80	12.7	14	577	" " "
28	100.8	76	12.8	14	535	" " "

TABLE NO. 4—(*Continued*)

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1922						
Mar.						
3	100.8	72	12.7	14	485	Food as above
4	101	60	12.8	14	493	" " "
5	101	60	12.7	18	494	" " "
6	101	64	12.8	22	478	Check test 490. " " "
8	101	68	12.8	18	476	" " "
9	100.8	60	12.8	18	455	" " "
10	100.8	54	12.9	18	484	" " "
11	100.8	60	13	22	526	" " "
12	100	84	12.8	22	568	Check test 563. " " "
13	100	60	12.8	14	478	" " "
14	100.8	70	12.9	16	569	" " "
15	100	64	12.9	14	475	" " "
16	100	64	12.9	14	529	" " "
17	100	58	12.9	14	512	" " "
18	100.2	85	12.8	14	617	Check test 605. " " "
19	100	64	12.9	16	479	" " "
20	100	66	12.9	14	561	" " "
21	100	64	12.7	14	509	" " "
22	100.2	62	12.8	14	516	" " "
23	100.2	72	12.8	16	536	" " "
24	100	64	12.9	14	526	" " "
25	100	68	12.9	14	558	" " "
26	100	64	12.9	16	518	" " "
27	100	68	12.9	14	493	" " "
28	100.2	68	13	18	573	" " "
29	101.3	68	13	22	462	" " "
30	101.3	68	12.9	16	496	" " "
31	101.3	60	13	14	503	Check test 511. " " "
Apr.						
1	100.8	72	13	14	490	" " "
2	101.3	70	13	14	510	" " "
5	100.6	72	13	18	540	" " "
6	100.6	64	13	18	560	" " "

period. The heat production per kg. of body weight on the last day of the fast was 42.4 calories per kg. of body weight. There was a slight but constant decrease in the body temperature of the dog during the last 17 days. The pulse rate decreased somewhat irregularly throughout the fast. The lowest pulse was 40 per minute.

The Period after Fasting (December 23rd to May 5th). No symptoms of gastric or other disturbed conditions were caused by breaking the fast. On December 23rd the dog was fed 50 g. of uncooked meat, 100 g. of bread, and 375 cc. of milk. The basal metabolism the next morning was 45.9% higher than what it had

been on the previous day. The dog was probably not in the post-absorptive condition, since only 12 hours had passed since feeding. This is the only one of the subjects that showed a marked increase in the basal metabolism the first day after eating. It was also the only subject that received and retained uncooked meat on the day that the fast was broken. Experimentation on this dog was interrupted from December 24th to January 3rd. During these days she received the diet of the stock animals in the laboratory. On and after January 3rd the animal received the maintenance diet of the control period until its initial body weight was reached and the experimental conditions were comparable to those of the control period in every possible way.

The Basal Metabolism. The average daily heat production for the entire after fasting period (January 3rd to May 5th) was 535.6 calories. The average body weight was 10.8 kilos. The average heat production per 24 hours per average kg. of body weight was 49.6 calories, an increase of 13.28% above the average control metabolism. The after fasting period of this dog, as in case of Dog No. 1, is best interpreted by subdividing the period so that the effect of the metabolism during the rapid increase in body weight and the estrual cycle can be separately presented. The average number of calories of heat produced from January 3rd to March 28th (body weight normal) was 554. The average body weight was 10.1 kilos. The average number of calories of heat produced per average kg. of body weight was 54.8, an increase of 27.7% above the average normal control metabolism. The average body weight of this dog from March 28th to May 5th was 12.39 kilos. The average daily heat production was 496.4. The average heat production per average kg. of body weight was 40.3 calories, 6% below the control.

The Basal Metabolism during the Estrual Season (April 18th to May 5th). The average heat production for this period of 18 days was 492.5 calories. The average body weight was 12.5 kilos. The average number of calories of heat produced per average kg. of body weight was 39.4. The average basal metabolism for a period of 18 days immediately preceding this rut was 502.1 calories. The average body weight was 12.3 kilos. The average number of calories per average kg. of body weight per 24 hours was 40.8. The basal metabolism during the rut was 3.4% lower than the basal metabolic rate for an equal number of days immediately preceding the rut.

TABLE NO. 5

Daily Data for Subject Dog No. III

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1921	**A. Control Period**					
Oct.						
17	101	74	12.2	16	532	250 g. meat, 100 g. bread, 250 c.c. milk
18	101	74	12.2	16	526	Food as above
19	101	66	12.1	16	528	" " "
20	101	78	12.2	14	528	" " "
21	101	66	12.2	14	503	" " "
22	101	76	12.3	16	512	" " "
23	101	78	12.2	16	513	" " "
24						Mechanical difficulties.
25						Mechanical difficulties.
26	100	66	12.2	12	544	" " "
27	101	74	12.2	16	528	" " "
28	100	66	12.2	16	501	" " "
29	100	74	12.2	14	472	" " "
30	100	76	12.1	12	533	" " "
31	101	76	12.1	16	519	Check test 522. " " "
Nov.						
1	101	76	12.1	12	526	" " "
2	101	76	12.1	16	503	" " "
3	101	76	12	16	490	Check test 490. " " "
4	101	76	12	16	491	" " "
5	101	74	12.1	16	491	" " "
6						Data discarded due to shivering.
7	101	78	12	16	517	Food as above
8	101	76	11.8	16	525	" " "
9	101	72	11.8	16	490	" " "
10	101	60	12	16	538	" " "
11	101	66	12	16	529	" " "
12	101	66	12	16	518	Last food at 8:00 A.M.
	B. Fasting Period					
13	101	66	12	16	509	1st Fast Day
14	100.8	66	11.8	16	527	Check test 527. 2nd " "
15	100.1	60	11.3	16	516	3rd " "
16	100.5	63	11.2	16	491	4th " "
17	101	60	11.1	18	477	5th " "
18	101	60	10.7	16	523	6th " "
19	101	60	10.5	16	430	7th " "
20	101	60	10.3	18	440	8th " "
21	100.8	62	10.2	18	476	9th " "
22	100.9	64	10	16	422	10th " "
23	100.9	64	10	16	461	11th " "
24	101	64	9.9	14	427	12th " "
25	101	62	9.7	14	464	13th " "
26	101	62	9.4	12	406	14th " "
27	101	62	9.2	12	395	15th " "
28	100	60	9.2	12	355	16th " "
29	99.5	54	9	12	349	17th " "
30	100	54	8.9	10	389	18th " "
Dec.						
1	100.8	50	8.8	10	351	19th " "

TABLE NO. 5—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1921	**B; Fasting Period—**	*Continued*				
Dec.						
2	100.8	52	8.7	8	361	20th " "
3	101	48	8.6	8	339	21st " "
4	101	60	8.4	8	385	22nd " "
5	101	48	8.3	10	314	23rd " "
6	100.8	46	8.2	8	330	24th " "
7	99.8	48	8.1	7	335	25th " "
8	100	48	8	7	349	26th " "
9	100	48	8	8	356	27th " "
10	100	48	7.9	8	362	28th " "
11	100	48	7.7	7	337	29th " "
12	100	40	7.6	7	352	30th " "
13	99.6	46	7.4	7	329	31st " "
14	99.6	40	7.2	7	305	32nd " "
15	99.6	44	7	6	314	33rd " "
16	99.4	42	6.9	6	318	34th " "
17	99.6	40	6.8	7	300	35th " "
18	99.4	40	6.8	8	314	36th " "
19	99.4	40	6.7	7	284	37th " "
20	100	44	6.7	6	310	38th " "
21	99.4	46	6.7	6	294	39th " "
22	99.4	46	6.6	6	281	40th " "
23	99.4	46	6.6	6	280	30 g. meat, 10 0g. bread, 1 pint milk at 5:00 P.M.
	C. Period After Fasting					
24	99.6	52	6.9	10	408*	50 g. meat, 1 pt. milk, 100 g. bread
1922						
Jan.						
3	101	68	7.4	12	331	250 g. meat,100 g.bread, 250 c.c. milk
4	101	68	7.4	12	371	Food as above
5	101	60	7.5	14	381	" " "
6	101	76	7.6	12	432	" " "
7	99.6	60	8	12	403	" " "
8	102	62	8.1	14	460	" " "
9	101	62	8.1	12	494	" " "
10	101	80	8.2	12	447	" " "
11	101	66	8.6	14	434	" " "
12	101	66	8.6	16	474	" " "
13	101	66	8.7	12	517	" " "
14	100.8	66	8.7	14	461	" " "
15	101	70	8.8	12	487	" " "
16	100.8	70	8.8	12	566	" " "
17	101	68	8.8	16	478	" " "
18	101	66	8.8	12	407	" " "
19	101	72	8.9	12	513	" " "
20	102	80	8.9	12	502	" " "
21	101	76	8.9	12	517	" " "
22	100.6	70	9	12	527	" " "
23	100.6	70	9	16	452	" " "
24	100	74	9.1	16	496	Check test 496. " " "
25	100.8	68	9.2	16	476	" " "
26	100.6	72	9.4	14	554	" " "

*Dog was evidently not in the post-absorptive condition.

TABLE NO. 5—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1922	**C. Period After Fasting—**					*Continued*
Jan.						
27	100	64	9.6	16	510	250 g. meat, 100 g. bread, 250 c.c. milk
28	100.2	82	9.8	16	510	Food as above
29	100	80	9.9	12	540	" " "
30	99.8	70	10	14	649	Check test 649.6. " " "
31	99.8	68	10.1	16	653	" " "
Feb.						
1	99.8	76	10.2	16	524	" " "
2	100.4	62	10.3	14	606	" " "
3	100.4	80	10.3	16	568	" " "
4	100.4	68	10.3	16	556	" " "
5						Mechanical difficulties.
6	99.8	70	10.2	18	554	" " "
7	100	76	10.2	14	581	" " "
8	100.2	76	10.1	16	584	Check test 580. " " "
9	100	72	10	16	631	" " "
10	100.2	70	10	16	626	" " "
11	100.4	62	10.1	16	519	" " "
12	101	86	10	16	604	" " "
13	100	80	10.2	18	632	" " "
14	101.5	82	10.3	14	540	Check test 530. " " "
15	100.8	82	10.3	16	580	" " "
16	100.8	86	10.3	16	578	" " "
17	100	86	10.4	16	582	Check test 574. " " "
19	99.8	86	10.5	16	600	" " "
20	99.8	88	10.5	16	602	" " "
21	100	86	10.6	14	684	Check test 700. " " "
22	99.8	80	10.7	16	588	" " "
23	99.8	86	10.7	18	631	Check test 625. " " "
24	99.8	80	10.8	14	610	Check test 602. " " "
25	100	80	10.8	12	710	" " "
27	100	68	10.8	16	732	Check test 742. " " "
28	100	68	10.9	16	713	" " "
Mar.						
1	99.8	70	10.9	16	655	" " "
3	99.8	72	11	14	550	" " "
4	99.8	70	11.1	16	525	" " "
5	100.2	68	11.1	14	570	Check test 582. " " "
6	100	84	11.2	14	699	Check test 687. " " "
7	99.8	84	11.1	14	605	" " "
8	100	68	11.3	16	559	Check test 564. " " "
9	100	82	11.4	16	651	Check test 651. " " "
10	100	64	11.5	16	551	Check test 551. " " "
11	99.8	60	11.6	18	665	" " "
12	100	78	11.6	18	629	" " "
13	99.8	80	11.7	16	673	" " "
14	99.8	80	11.8	18	536	" " "
15	100	88	11.8	18	614	" " "
16	100	78	11.8	18	627	Check test 636. " " "
17	99.8	60	11.8	18	583	" " "
18	99.8	60	11.7	18	524	" " "
19	100.6	80	11.5	18	569	" " "

TABLE NO. 5—*Continued*

Date	Temp. in F°	Pulse Rate per Min.	Wt. in Kilos	Resp. per Min.	Cal. per 24 Hrs.	Remarks
1922	**C. Peri**	**od Aft**	**er Fas**	**ting—**	*Contin*	*ued*
Mar.						
20	100.6	60	11.6	18	578	250 g. meat, 100 g. bread, 250 c.c milk
23	100	64	11.7	16	513	Food as above
24	100.2	80	11.8	18	514	" " "
25	99.8	68	11.8	14	514	" " "
26	99.8	60	11.9	16	597	" " "
27	100	60	11.9	18	598	" " "
28	99.0	60	12	18	484	" " "
29	100	68	12.1	18	464	" " "
30	100	60	12.1	18	483	" " "
31	100	64	12.2	16	453	" " "
Apr.						
1	99.8	80	12.2	20	443	" " "
2	100	60	12.2	16	476	" " "
4	100.8	60	12.2	20	464	" " "
5	100.8	60	12.3	20	471	200 g. meat, 50 g. bread, 250 c.c. milk
6	100	68	12.4	20	471	Food as above
7	99.8	64	12.1	20	522	" " "
8	99.8	64	12.3	20	528	" " "
9	100	58	12.3	16	466	" " "
10	100	54	12.3	16	453	" " "
11	99.8	68	12.3	16	507	" " "
12	100	72	12.3	20	616	" " "
13	100	68	12.3	18	571	" " "
14	100	64	12.3	18	568	" " "
15	100	64	12.4	18	478	" " "
16	99.8	64	12.3	16	500	" " "
17	99.8	64	12.4	16	568	" " "
18	100.2	60	12.4	14	491	Indications of Rut. " " "
19	99.8	64	12.4	14	517	" " "
20	100	60	12.4	12	466	" " "
21	101	64	12.4	16	482	" " "
22	101	80	12.5	18	516	" " "
23	101	72	12.4	18	516	Check test 517. " " "
24	99.8	68	12.5	16	527	Check test 518. " " "
25	99.8	64	12.6	22	460	" " "
26	99.8	72	12.6	16	483	" " "
27	100	68	12.6	16	572	" " "
28	100	68	12.6	20	469	" " "
29	99.8	68	12.6	16	443	" " "
30	99.8	68	12.6	16	445	" " "
May						
1	100	64	12.6	20	467	" " "
2	99.8	64	12.5	16	461	" " "
3	99.8	68	12.6	16	477	" " "
4	99.8	68	12.6	16	589	" " "
5	100.2	68	12.6	16	485	" " "

Discussion of Results.

The Control Period. Daily variations occurred in the basal metabolism of all subjects. The variations were greater for the period after fasting than for the pre-fasting period. The greatest deviation from the average for any subject during the control period was an increase of 13.6% and a decrease of 9.8%. The daily determinations for each subject can be found in Tables 1, 2, 3, 4 and 5. If the metabolism of any subject per unit of body weight be compared month by month during the same season of the control period, a striking uniformity in the results becomes apparent. Thus in the case of subject M. K., the average daily heat production per kg. of body weight for the month of July was 24.73 calories, for August 24.76 calories, in spite of the fact that daily variations during some of this time were exceedingly great. On August 29th the total heat production was 1267 calories. On August 13th the total number of calories for 24 hours reached 1476. Similar results can be found in the data of the dogs.

In many instances the increased metabolic rate was accompanied by an increase in pulse rate or a very slight increase in temperature but the numerous exceptions to this gives further evidence of the fallacy in attempting to apply mathematical precision to such functional relationships as pulse rate and intracellular oxidation.

The data presented in Tables 1, 2, 3, 4 and 5 proves conclusively that a single basal metabolism determination (using short periods and indirect methods) is unreliable and cannot be used for accurate comparisons in research work. However, there are many times when daily differences were less than 1%, but variations of 6% to 12% are of frequent occurrences in the basal metabolic rates of both man and dog.

The control period for dog No. 1 was much shorter than for either of the other dogs. The basal metabolism for this dog appears to be remarkably constant but this is apparent rather than real. The reason for the discrepancy is that tests which showed marked variation were discarded, on the assumption that the technique was faulty and that there is no variation in a normal dog's basal metabolism. It was later found that when all experimental factors were controlled, the dog motionless, and 18 hours after feeding, variations in the metabolism still occurred occasionally, if tests were carried on over a period of time, using this indirect method and 15 minute periods.

The respiratory rate seemed to have but little effect on the total heat production. The marked changes in the respiratory rate in case of the dogs occurred not because of appreciable changes in the room temperature but during sultry mornings and seemed to be due to an increase in humidity.

The Fasting Period. The ability to withstand the fasting varied with the several subjects. F. H. continued his daily occupation in the flour mill and since he has experienced previous fasting periods of even longer duration than this, he did not seem to be at all disturbed by the starvation except for the relatively small loss in body weight and a diminution of the pulse rate which occurred on the 15th fast day. The small loss in body weight of the subject can probably best be explained on the basis of the experiments of Howe and Hawk[16] on "repeated fastings." They conclude that a repeated fast is accompanied by less nitrogen loss from the body than from an original fast.

The subject M. K. also continued her daily occupation as described under methods. On the morning of the second, third and fourth fasting days there was a feeling of weakness and a tendency to perspire freely on the least exertion. The buccal mucous membrane became very dry after the first few days. This dryness neither created thirst nor seemed to be relieved by drinking water, in fact the desire for water was almost nil. If an increase in the water intake of a fasting organism stimulates nitrogen catabolism, it would seem to follow that this lack of thirst is a mechanism for conserving the forces of the starving body. Enemas were given on the third, fourth, sixth and eleventh fasting days. Spontaneous bowel movements occurred on the 12th and 13th days of the fast. Menstruation began on the 12th day (a few days in advance of the normal cycle) and seemed normal in every way. The muscular weakness was exceedingly great on and after the 13th day. On the 14th day there was some nausea accompanied by marked general weakness and distress. At the end of the 15th day, the muscular weakness was such that climbing four flights of stairs at 5 P. M. seemed almost impossible; in fact, the subject was obliged to rest at the top of each flight. There was no time during the 15 days of fasting when the subject felt entirely free from hunger. No change occurred in the pulse rate or body temperature during the fast.

Individual variations occurred in the reaction of the three dogs to the starvation. Dog No. 1 was depressed during much of

the time. It vomited occasionally and showed other symptoms of disturbance that may have been caused by the cooked bones fed to it. On the 37th day it was in a moribund state, refused food, and vomiting followed each attempt at forced feeding. On the 3rd day after fasting, the vomiting ceased. The dog displayed no further symptoms of functional disturbances.

Dog No. 2 received smaller portions of bone and endured the fasting much better. However, on the 40th fast day, the animal's general condition was very wretched. It refused food, could not stand alone and displayed symptoms of central nervous system disturbances. When forced to its feet it walked in a circle. Nystagmus was present. The dog was unable to retain nourishment for the first 3 days after the fasting. On the 2nd day it was seized with violent convulsions which seemed to be aggravated by the sensory stimulation involved in caring for it. During these convulsive seizures, the dog's head was retracted and the four legs extended. Vomiting ceased on the 3rd day after fasting, the convulsions on the 4th day; no further disturbances were observed.

Dog No. 3 (the older animal) gave no signs of functional disturbance during the 41 days of starvation. The body became extremely emaciated. The pulse rate diminished and there was a slight lowering of the rectal temperature. No gastric disturbance or other symptoms of distress were observed as a result of breaking the fast.

Cooked bones were fed to dogs No. 1 and No. 2 from time to time during the starvation period, on the assumption that they contained no food value but would serve to keep the animals more content and in a better physiological state by stimulating bowel movements. But the effect of feeding the bones to fasting dogs seems deleterious rather than helpful, since dogs No. 1 and No. 2 received bones and were markedly disturbed while dog No. 3 received no bones, fasted longer and showed no functional disturbances either during or on breaking the fast.

The Basal Metabolism during Fasting. The most striking feature of the fasting metabolism of these five subjects was the marked increase in the basal metabolic rate which occurred during the first part of the fasting period of the two people usually apparent on the 2nd or 3rd fasting day. The metabolic rate for the entire 15 fast days for M. K. was higher than normal. For F. H. it approached the normal level on the 9th day but never fell

below that of the lowest normal, even on the 15th day of starvation.

Dogs No. 1 and No. 2 maintained a higher metabolic rate than normal while the basal metabolism of dog No. 3 remained remarkedly constant throughout the entire 41 days of starvation (excepting the slight rise on the 6th day). These studies on fasting metabolism do not conform to the conclusions drawn by Benedict[18] on the basis of his experiments on fasting people, i.e., that the first period of a fast is characterized by a rapidly falling metabolism followed by a period of level metabolism and finally a tendency toward an increase in the basal metabolic rate. It should be noted in this connection that in converting the cc. of O^2 consumed into calories of heat, I have assumed that the respiratory quotient was .82. This, of course, is not true for the fasting period since the respiratory quotient for all subjects was probably near .71 during the fasting period. This would change the calorific value of the O^2 consumed so that the total number of calories of heat computed for each subject during this period is about 2% too high. The high fasting metabolism of dogs No. 1 and 2 is no doubt due to their unusually disturbed conditions.

Period after Fasting.

Body Weight of the Two Persons. The period after fasting for M. K. was of six months' duration. The ingestion of the first food after fasting is very interesting in that the physiological effects can scarcely be explained on the basis of the caloric value of the food eaten. On September 28th (last fast day) at 5:00 P. M. the general feeling of weakness and distress was very great as noted above. At 6:00 P. M. an orange (about 100 calories) was eaten. In a very short while the feeling of great weakness and distress had given place to a feeling of normal muscular strength and well-being. At 6:30 a bullion cup of tomato soup (200 calories) was eaten. Shortly after this the subject descended four flights of stairs, walked about in the neighboring park for an hour, returned and climbed the four flights of stairs without the least feeling of fatigue. Another bullion cup of tomato soup was eaten before retiring. The basal metabolism was 2.5% lower the next morning than it had been at any time during the fasting period. The pulse rate was normal.

The increase in body weight following starvation was amazingly rapid. By the end of the 7th day after fasting the body

had gained 17.38 lbs., the weight was back to normal in spite of the fact that during the first five of these days only one moderate meal a day had been eaten. It seems that the mechanism by which the cells of an extremely emaciated body, rendered thus by starvation but organically sound, utilizes food, must be quite different from that which occurs after emaciation from sickness, when not only body substance must be built up, but functional disturbances corrected as well. Certainly the body is not able to utilize food on such an economic basis under ordinary conditions of nutrition. After the body weight had returned to normal (55.1 kilos.), the increase continued slowly until a weight of 57.5 kilos. had been reached. Following this there were variations from 57.5—57.2 throughout the entire period. The actual gain in body weight over the control period was 1.8 kilos.

No changes were detected in the temperature or the pulse. The appetite was unusually keen for about two months after the fast had ended. The bowel movements were more regular for at least two months after the fast.

The body weight of the subject F. H. increased 18.2 lbs. during the first week after fasting (December 3-11). At the end of the period (February 14) the weight was 65 kilos., an increase of 7 lbs. over the initial weight. The pulse rate of this subject showed a slight increase as a result of the fasting.

The feeling of well-being and apparent increase in energy experienced by these two people conform to the results described by Carlson[19] after a five-day fast.

It is difficult to attempt a discussion of the rapid increase in body weight of the two persons, since quantitative determinations of the dietary were not made. It is possible that the fasting caused a hydration and that part of the rapid increase in weight which occurred during the first 3 or 4 days, was due to an accumulation of fluids in the tissues rather than to an increase in body substance. But if this did occur, the fluids must have been rapidly replaced by active protoplasm, since the gain in weight was permanent and the increase in the amount of oxygen consumed after the first 4 or 5 days could not have been caused by inert water.

Body Weight of the Three Dogs. The time required for the dogs to recover their respective body weights of the control periods varied from 4 to 11 weeks (Tables 3-4-5). There was no astonishingly rapid increase in weight during the first days after

fasting as occurred with the two persons, but a uniformly progressive gain. Each dog daily received the carefully weighed maintenance diet of the control period until its initial body weight had been reached. Following this, the amount of food given each dog was gradually diminished in an effort to keep the body weight at the same constant level of the control period. The total reduction of the maintenance diet was such that the final dietary of each dog for this period had a fuel value of 643 calories, 218 calories less than the maintenance diet of the control period. In spite of this marked reduction in the amount of food ingested, the body weight of each dog was greater when experimentation ceased than it was during the control period.

Von Seeland[20] found that pigeons starved for a period of 15 days and subsequently fed attained a greater body weight than those of the same hatching that had not been starved. Noe[21] has observed a similar condition in regard to rats, mice, guinea pigs and rabbits. Dietrick[22] found that swine which had been starved for ten days and subsequently fed could be maintained in a condition of nitrogenous equilibrium on a diet much less than that which they received during the prefasting period.

These results seem to indicate that fasting, at least in some higher animals, causes a change in the ability of the cells to assimilate food. It seems that the body, reduced to its own resources, acquires an economy which changes the nutritive value of the food relative to a starved and an unstarved cell. The underlying principles of nutrition involved in such a process must be found in the hidden recesses of the living cell and cannot be deduced from a study of caloric values or chemical composition of foods. If these results signify an increase in the nutrition of the body, the effect of fasting should be investigated in connection with wasting diseases and diseases characterized by lowered nutritional conditions.

Basal Metabolic Rate after Fasting. The basal metabolic rate of both persons was lower on the day after fasting than it had been at any time during the fast. Subject M. K. remained low for the first 4 days of this period. Determination on dogs No. 1 and No. 2 were discarded because of their disturbed conditions during the first 4 days. Dog No. 3 showed a marked increase in the basal metabolic rate on the day after fasting probably due to retarded digestion and absorption and consequently prolonged specific dynamic effects of the meat eaten the previous day. Follow-

TABLE 6

Average results of the control, fasting and after-fasting periods, and the percentage deviation from the control metabolism.

Subject	Period Date Number of Days Number of Determinations	Average Number of Calories Produced per 24 Hrs.	Average Body Weight in Kilos	Average Number of Calories per Average Body Weight per 24 Hrs.	Percent Deviation from Control Metabolism
M. K.	Control July 1–Sept. 14 75 days 74 determinations	1354.8	55.1	24.58	
M. K.	Fasting Sept. 14-28 15 days 15 determinations	1403.2	50.3	27.8	+12.6*
M. K.	After fasting Sept. 29–Oct. 4 5 days 5 determinations	1292	51.3	23.2	− 5.6
M. K.	After fasting Oct. 5–Dec. 4 62 days 61 determinations	1465	56.2	26.07	+ 6.1
M. K.	Six months after fasting Oct. 4–Mar. 31 179 days 161 determinations	1475.7	57.2	25.79	+ 4.5
F. H.	Control Nov. 3–17 15 days 8 determinations	1435.7	61.1	23.4	
F. H.	Fasting Nov. 19–Dec. 3 15 days 8 determinations	1403.9	58.4	24.02	+ 2.6*
F. H.	After fasting Dec. 4–5 2 days 1 determination	1235	58	21.3	− 8.9
F. H.	After fasting Dec. 7–Feb. 14 70 days 17 determinations	1526.3	63.7	23.9	+ 2.1

TABLE 6—*Continued*

Subject	Period Date Number of Days Number of Determinations	Average Number of Calories Produced per 24 Hrs.	Average Body Weight in Kilos	Average Number of Calories per Average Body Weight per 24 Hrs.	Percent Deviation from Control Metabolism
Dog 1	Control Mar. 21–Apr. 9 19 days 7 determinations	360.1	10.2	35.3	
Dog 1	Fasting Apr. 9–May 16 37 days 36 determinations	305.3	8.04	37.9	+ 7.3*
Dog 1	After fasting May 19–June 19 32 days 32 determinations	383.4	9.1	42.1	+19.3
Dog 1	After fasting June 19–Aug. 2 44 days 43 determinations	407.5	10.2	39.9	+13.0
Dog 1	After fasting Aug. 28–Oct. 29 62 days 61 determinations	280	10.5	36.2	+ 2.2
Dog 2	Control July 9–Sept. 16 50 days 42 determinations	465.3	12.4	37.54	
Dog 2	Fasting Sept. 17–Oct. 27 40 days 39 determinations	391.8	9.78	40	+ 6.7*
Dog 2	After fasting Nov. 1–Jan. 4 65 days 55 determinations	483.7	10.7	45.2	+20.4
Dog 2	After fasting Jan. 4–Apr. 6 92 days 80 determinations	515.6	19.9	39.98	+ 6.5
Dog 3	Control Oct. 17–Nov. 12 27 days 24 determinations	515.5	12	42.9	

*Values are 2-3% high due to lowered respiratory quotient of fasting.

TABLE 6—*Continued*

Subject	Period Date Number of Days Number of Determinations	Average Number of Calories Produced per 24 Hrs.	Average Body Weight in Kilos	Average Number of Calories per Average Body Weight per 24 Hrs.	Percent Deviation from Control Metabolism
Dog 3	Fasting Nov. 13–Dec. 23 41 days 41 determinations	379.4	8.73	43.45	+ 1.2*
Dog 3	After fasting Jan. 3–Mar. 28 75 days 69 determinations	554	10.1	54.8	+27.7
Dog 3	After fasting Mar. 28–May 5 39 days 34 determinations	496.4	12.39	40.3	− 6

ing this all subjects showed a marked increase in the oxygen consumption per unit of body weight which was apparent for at least two months. After this there was a tendency to return to normal as can be seen from Table 6, but the exact level of the normal was never reached for the subjects M. K. and Dog No. 1.

TABLE NO. 7

Subject	Duration of Fast in Days	Percent Loss in Initial Body Weight	Percent Increase in B. M. R. 1–3 Months After Fasting
Dog No. 1	37	39.3	+19.3
Dog No. 2	40	42	+20.4
Dog No. 3	41	45	+27.7
M. K.	15	14.3	+ 6.1
F. H.	15	10.2	+ 3

The increased oxygen consumption after fasting cannot be attributed to an increase in the caloric intake of food because the dietary of the dogs for about two months after starvation was quantitatively the same as the maintenance diet of the control period. Voit's principle states that the intensity of metabolism in the cell is modified by the kind and amount of food brought to the cell

by the blood. It is conceivable that starvation causes a change in the permeability of the cell membranes in such a way that more food is able to reach the cell after starvation than before. This would result in an augmentation of the metabolism of the cell by the presence of increased quantities of food stuffs. If the cell membranes of young cells are more permeable to food stuffs than the membranes of older cells, the increase in metabolism which is characteristic of the young may be explained on Voit's theory. Child terms the increased oxygen consumption which occurs in starving planaria a process of "rejuvenescence." Allen[23] points out that after fission in a worm, the tail piece which becomes organized into a smaller sized worm shows a higher rate of oxygen consumption per unit of body weight. Hyman[24] finds a similar condition accompanying the regeneration of worms that have been cut into small pieces. DuBois has found that the basal metabolism of convalescents after typhoid fever may reach an increase of 17% above the normal. DuBois[25] notes that this heightened metabolism "is reminiscent of the increased heat production occuring during the period of growth."

It becomes evident that where the initial weight was reduced by 45%, and subsequently restored by the normal diet, approximately one-half of the restored body is made up of new protoplasm. In this there is rejuvenescence. But the fact that there is a tendency for the metabolic rate to return to its former level points to internal co-ordinating processes that are not permanently altered by fasting. The establishment for a period of months of a metabolic level, somewhat higher than normal, is probably due to improved nutrition due to the replacement of new cells for less resistant ones that were used to supply the body during the fasting.

This increased heat production after fasting is no doubt analogous to the increased metabolic rate which occurs during the period of growth in the young. In the case of the dogs, the first two months after fasting represents the most rapid regeneration of body tissues. During this time the food was not increased but the O_2 consumption was markedly increased. The increased oxygen consumption parallels the anabolic processes of transforming the energy of the food into living protoplasm. The O_2 consumed during the anabolic processes of building up tissue protein does not seem to conform to the oxygen consumed during catabolic processes as explained by methods evolved from a study of "bomb calorimetery."

Carlson suggests that the higher metabolism after prolonged fasts may be due to a temporary excess activity of such glands as the thyroid and the gonads, glands that seem to have direct effects on the metabolic rate. It is well established that fasting induces marked atrophy of these glands. The recuperation of these glands, on resumption of eating, may carry them, for a while, beyond the level of activity normal for the age of the subject. This would in all probability lead to a higher basal metabolism. We have data indicating increased activity of the gastric glands[27] following prolonged fasts.

Effect of the Estrual Cycle on the Basal Metabolism. The exact time of the beginning of rut is difficult to determine, but with these dogs a few drops of bloody discharge from the vagina could be detected on the pad where they lay during the metabolism tests. Perhaps most bitches discharge a slight amount of bloody fluid during this period, but it may not be generally observed because of its small quantity and the habits of cleanliness that characterize dogs. The only time that the discharge was noticed was during the period of taking the basal metabolism. It should be recalled that during these periods the dogs lay motionless for at least one hour so that discharges that ordinarily would have been removed accumulated in noticeable quantities. From Table 8 it can be seen that there was no increase in the B. M. R. during rut, but in two of the periods there was a decrease of from 3.4-4% while the one period shows no change. This precaution should be mentioned in making metabolism determinations on dogs in heat; it was difficult to get Dog No. 1 perfectly quiet at the beginning of the rest period. She seemed unusually alert and ready to respond to the least movement about her. But once having become perfectly quiet and relaxed she remained in the same motionless condition previously mentioned.

After the rut had ceased (August 26) there was a marked lowering of the basal metabolism which persisted until about the 27th of October. After this the metabolism became high and remained so until the end of the second rut season. The highest being the ten days immediately preceding the second rut season. The average basal metabolism during the post-estrual cycle (August 28 to October 27) was 380 calories per day. The average body weight was 10.5 kgs. The average number of calories of heat produced per 24 hours per average kg. of body weight was 36.2. This is a decrease of 8.12% below the average metabolism for the

TABLE NO. 8

Dog	Period	Average Number of Calories per Kg. of Body Wght.	Percent Deviation of Metabolism During Rut from an Equal Number of Days Preceding Rut
No. 1	23 days preceding rut, July 12–Aug. 3, 1921	39.2	
No. 1	Rut—Aug. 4–26, 23 days	39.4	
No. 1	15 days preceding rut, Jan. 29–Feb. 12, 1922	44.5	
No. 1	Rut—Feb. 14–28, 15 days	42.7	−4%
No. 3	18 days preceding Mar. 30–Apr. 17	40.8	
No. 3	Rut—Apr. 18–May 5, 1922, 18 days	39.4	−3.4%

estrual season. It is to be regretted that metabolism determinations were not continued for at least two more months to determine whether the post estrual drop would again occur.

These experiments suggest a lowering of the metabolism during the latter part of the estrual cycle, followed by a still lower rate for a considerable period after the rut, after which there is a rise which reaches its greatest level just before the appearance of the next rut. Since the estrual cycles here cited all occurred after fasting, the fluctuations described may have had little bearing on the condition of rut per se.

Effect of Menstruation on the Basal Metabolism. Comparisons of the average basal metabolism of the first four days of menstruation and the average metabolism of the four days preceding menstruation can be found in Table 9.

From the Table it can be readily seen that the deviation of the metabolism during the first four menstrual days from the preceding four days is not constant. This conforms to the results obtained by Blunt[26]. But the tendency seems to be towards a lowering of the basal metabolism during the first four days of menstruation.

Seasonal Variation. A slight tendency toward a seasonal variation can be seen in the metabolism of the Subject M. K. Determinations in this case were made over long periods of time before

TABLE NO. 9

Average Computed from Table 1

First Four Days of Menstrual Periods	Average Number of Calories for Four Menstrual Days	Four Days Immediately Preceding Menstruation	Average Calories for Four Days Preceding Menstruation	Percent Variation Metabolism During First Four Menstrual Days and Four Preceding Days
April 5–8	1455	April 1–4	1494	−3.4
May 5–8	1440	May 1–4	1428	+ .8
June 1–4	1366	May 28–31	1350	+1.1
June 29–2	1362	June 25–28	1438	−5
Aug. 3–6	1337	July 30–2	1367	−2
Aug. 30–2	1331	Aug. 26–29	1361	−2.2
Sept. 25–28	1309	Sept. 21–24	1344	−2.6
Oct. 31–3	1409	Oct. 27–30	1509	−7.2*
Nov. 28–1	1496	Nov. 24–27	1439	−4
Jan. 26–29	1471	Jan. 22–25	1337	+1.6
Feb. 24–27	1529	Feb. 20–23	1555	−2

*First period after fasting.

and after the fasting. The metabolism of this subject during July and August was slightly lower than it was during any other month of the year.

TABLE NO. 10

Seasonal Variation

Subject	Month	Average Heat Production per Day	Average Body Weight	Average Number of Calories per Average Kg. of Body Weight	Percent Deviation from April Metabolism
M. K.	April, 1921	1427	55.2	25.86	
M. K.	July, 1921	1365	55.2	24.73	−4.3
M. K.	August, 1921	1362	55.1	24.76	−4.2
M. K.	March, 1922	1499	57.3	26.16	1.16

The seasonal variations of the dogs cannot be accurately distinguished from the effects of fasting and the estrual cycle.

Summary.

1. A muzzle was perfected, and a method devised by means of which the gaseous respiratory exchange of dogs can be accurately determined from either a closed or an open respiratory system.

2. Daily variations appear in the basal metabolic rate of both man and dog. Average results over periods of 3 or 4 weeks are remarkably uniform per unit of body wt.

3. The pulse rate does not always parallel the basal metabolic rate and therefore is not a reliable index of the cellular metabolism.

4. The basal metabolic rate during the initial days of fasting in man may be much higher than normal. A fast of 41 days in dogs and 15 days in man causes no appreciable lowering of the basal metabolic rate during the fasting period.

5. Dogs, fasted until their initial body weights had been reduced 39-45%, not only regained their normal weights but gained weight on the same dietary which before fasting merely maintained their body weights constant. After the fast they maintained normal weight on a lower calory intake. This indicates a more economical use of the food. It is not due to decreased general activity.

6. There is a temporary increase in the basal metabolic rate as an effect of prolonged fasting. This temporary increase seems to be proportional to the duration of the fast and loss in body weight.

7. The increased oxygen consumption in dogs was most marked during the time that the body was undergoing rapid growth or gain in weight.

8. The basal metabolic rate of female dogs during rut is normal or slightly lower than normal.

9. The basal metabolic rate during the first four days of menstruation is usually slightly subnormal.

10. There are indications of seasonal variations in the basal metabolic rate of man.

I wish to thank Professor Carlson for having planned the problem and for helpful criticisms during the completion of the plans.

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